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MR. JOSEPH GILLOTT.

MR. GILLOTT AND THE STEEL-PEN TRADE.

AS we take up the pen—a steel pen, of course—to begin this paper, the temptation is almost irresistible to go back in imagination to the far-off days when it was thought a triumph of ingenuity to trace written characters with a metal point upon tablets coated with wax; and so to come downwards on "the stream of time" with each successive improvement in the history of writing implements and materials, from the reed and the papyrus to the hot-pressed "Bath post" and the fine goose quill, and so to the infinite varieties of pens and papers now in use. What a volume might be written in illustration of the march of civilization and the development of human ingenuity! How the characteristics of nations would freshen out of the fading colours of the past! What a store of gossip might be told of famous writers—how poetry and romance, legend and song, wit and humour, the stately march of history, the records of commerce, the mysteries of theology, the speculations of philosophy, the discoveries of science, the vast fields of literature, and the familiar details of homely life, would all weave themselves—a wondrous coloured web—into the history of that little instrument, the Pen—"the silent mouthpiece of the mind, which gives ubiquity and permanence to the evanescent thought of a moment!" But ours is no such lofty task. We have to deal with the pen in its most prosaic aspect—that of manufacture; and here only with one kind, the Steel Pen, unknown a generation ago save to the curious, but now familiar throughout the world, from the cabinets of princes to the hut of the Australian bushman.

Even this task, however, is one of no ordinary difficulty. Recent as it is, and familiar as it should be, the early history of the steel pen is curiously obscure. The most diligent search fails to discover the first maker or the earliest date of this implement. There were steel, or rather iron pens—made, we believe, in Holland—as early as the middle of the seventeenth century. One of them, enclosed in a neatly-fitted writing-case, formerly belonging to some unknown Dutch merchant, is now in the possession of Mr. Bragge, of Sheffield—a much prized specimen in his vast collection of rarities: snuff-boxes, pipes, uncut gems, priceless books, and gorgeous missals. Towards the close of last century, Mr. Harrison, an ingenious Birmingham mechanic, made steel pens for Dr. Priestley. One of them is still preserved by Mr. Harrison's business successor, Sir Josiah Mason, who shows it sometimes to his friends; and it is nothing more than a tube turned out of a flat strip of metal, with the sides and point filed away into the shape of a pen. The first actual supply of such pens, it is believed—the authority for the statement is no more than local tradition—was made by a Sheffield workman, whose name is forgotten. From time to time, as far back as 1809, steel pens, hand-fashioned, turned and filed, were made as curiosities or luxuries for presents; but it was not until about 1824 that such instruments were produced in considerable quantities, as regular articles of manufacture. Mr. James Perry, whose name was afterwards famous in connection with "the Perryan Pen," was the first manufacturer; but the process was tedious, the progress slow, and the product costly. Mr. Perry had many difficulties, both with regard to his workmen and the quality of steel best adapted for use. The metal was obtained from Sheffield—ribbon steel, rolled out of wire—and for this Mr. Perry paid as much as seven shillings a pound. To the first person he employed he gave five shillings for making each pen; and even when the trade had become regular he gave for some years as much as thirty-six shillings per gross to his workmen. Now—thanks to machinery and to modern improvements—pens, not very good perhaps, but good enough to write with, can be made and sold at a profit for $1\frac{1}{4}d.$ per gross!

The first great impulse to the steel pen trade was given in 1829, when Sir Josiah Mason and Mr. Gillott began pen-making. In the sketch of the former ("Practical Magazine," No. III.), we gave an account of his introduction to the trade, through buying one of Perry's pens, then sold at 3*s.* 6*d.* each. It was about the same time that Mr. Gillott began; and since then his name has become so closely identified with the trade, and has acquired such a world-wide reputation, that he has come to be regarded as *the* Pen Maker; and therefore we select his portrait and memoir, as the fittest which can accompany this notice of the history and manufacture of steel pens.

Though so long resident in Birmingham, Mr. Joseph Gillott was not a Birmingham man by birth. He was born in Sheffield, on the 11th of October, 1799, the son of a workman in the cutlery trade. His own youth was occupied in this business, in which he was both industrious and skilful; indeed, according to the account of old workmen, he was a noted "hand" at the forging and grinding of knife blades. In 1821, when Mr. Gillott was in his twenty-second year, trade in Sheffield fell off, and work being scarce, the young workman resolved to transfer himself to Birmingham, where, owing to the variety of occupations, a skilled mechanic need never be idle. It was a fortunate move, for Birmingham was the very place to help an ingenious man to fame and wealth, it being easy in most staple trades of the town for a workman to become a small master, and thus by degrees to push his way into the ranks of manufacturers; and if he have skill, industry, and self-control, to stand at last in the front rank of all. This, in little, is the history of Mr. Gillott's progress. He reached Birmingham a stranger, but was cheered on his arrival by a friendly welcome at the inn at which he happened to stop for the night. Years afterwards, when he had become wealthy, Mr. Gillott bought this inn; and so strongly was his first visit to it impressed upon his mind, that he removed and preserved the bench upon which he originally sat. His earliest employment in Birmingham was in the "light steel toy trade"—the technical name for the manufacture of steel buckles, chains, and other works and ornaments of that kind. Some specimens of his workmanship in this trade Mr. Gillott always preserved. After being for a few years engaged in this trade, Mr. Gillott began the manufacture of steel pens. His faculty of invention and adaptation at once came into play. Such pens as were then made were laboriously cut with shears out of the steel, and were trimmed and fashioned with the file in imitation of the quill. There were no such things as the "slip" pen, which now constitutes the staple of the trade—the thin piece of metal "raised" from the flat. Mr. Gillott adapted the "press" to the making of pens—the stamping press, then much used in the Birmingham trades, and now familiar to everybody who has ever been in the shop of a metal worker. He saw that the press would enable him to dispense with most of the slow and laborious operations of pen making; that it would cut out the "blanks," slit them, bend the metal, stamp the maker's name, and thus, by mechanical means, render production at once rapid and certain. But the conception of this idea, and the means of working it out, were different matters. The metal had to be prepared by rolling, "pickling," and tempering for the action of the press. Then special dies had to be made for each size of pen, and for each operation of stamping to which the "blanks" had to be submitted. Presses of improved construction—quick, light, easily worked, and yet firm enough to strike a sharp, heavy blow—had to be made. And when these difficulties were overcome, there remained others not less formidable—such as tempering the metal after it had left the press; rendering the newly made pens flexible, so as to write easily; cleaning and polishing them without injuring their fineness; and coating them with some kind of varnish, so as to render them attractive to the eye. This was the work which Mr. Gillott had to do; and with much ingenuity and unflagging perseverance he accomplished it. By degrees the press was adapted to the cutting, slitting, bending, and marking processes; machinery was devised for cleaning and polishing the pens; experiments were made with different qualities of steel, and various ways of preparing it for use. At last Mr. Gillott attained the degree of excellence which has become intimately associated with his name; and other penmakers following his example, the trade has reached the importance, perfection, and extent which now characterize it.

It is impossible now to recall the innumerable steps by which the various improvements were effected. Probably only Mr. Gillott himself could have adequately described them; and he left no record of his early struggles. Indeed, being by habit a reticent man, he seldom spoke of them; though at times, in familiar conversation, he was not unwilling to recount some of the difficulties he met with, and the means by which he overcame them. One of the chief troubles was the extreme "hardness" of steel pens; when much used, they became pins rather than pens. After many trials Mr. Gillott effected a great and permanent improvement by cutting the side slits in addition to the centre slit which had been solely in use up to that period. To this was afterwards added the cross-grinding of the points; and these two processes perfectly succeeded in imparting elasticity to the steel pen, and bringing it up, in this respect, to an equality with "the grey goose-quill." It is, however, a curious fact—and one worth noting, if only as evidence of "character"—that Mr. Gillott himself never used a steel pen; he always wrote with the quill. For some years Mr. Gillott kept his methods of working secret, fashioning his pens with his own hands, assisted by a workwoman whom he afterwards pensioned; and many curious anecdotes of the early days of pen-making have been related by this old lady. She used, for example, to tell with great amusement how the first pens were "blued" in a frying-pan over a

garret fire. This was at the period when the pens were sold singly, at high prices. Even after the manufacture had been for some time established, the price kept up. Mr. Gillott has been heard to say that on his wedding-day he made seven pounds four shillings by producing a gross of pens, which he sold at a shilling each. At first he worked for others rather than for himself—all, or most, of his pens being sold to Messrs. Beilby and Knott, a firm of stationers existing in Birmingham forty years ago. Tradition says that one of the firm was the unintentional means of setting Mr. Gillott up in business for himself, by trying to beat down the price of the pens. On this the sturdy artizan, always most independent in character, declared that he would never make another pen for the firm ; and as the story goes, he did not, but made them for the trade generally. His business, when thus begun, grew rapidly. It was at first established in Bread Street, Birmingham, then removed to Church Street, then to Newhall Street, and finally to his great works in Graham Street, Newhall Hill, where it is still carried on. The means by which this growth was effected, and the character of the man who accomplished it, are well described by one who was intimately acquainted with him, Mr. Samuel Timmins, the editor of the excellent series of reports prepared in 1865 for the British Association, and collected in a volume entitled "Birmingham and the Midland Hardware Districts." In a brief notice of Mr. Gillott, published soon after his death in 1872, Mr. Timmins writes :—"Not only was his inventive power remarkable, but his love of order, his indomitable patience and persistence, his steady adherence to the line he had marked out, his quick business tact and shrewdness—all combined to make his wonderful success. Unlike most inventors, he was not content to devise, and to leave others to perfect, but he worked away with his own hands till his business so increased that further machinery was required. The simplicity, accuracy, and readiness of the machinery employed enabled him to produce steel pens in large quantities and to sell them at high prices, so that fortune flowed in upon him with wondrous rapidity. Until two or three years before his death he took an active part in his enormous business, extending over every part of the globe. He personally looked into every department, and was familiar with every detail. He might even be seen very late in life handling some of the old familiar tools, and trying improvements, although little further ingenuity was needed, for the machinery at first devised had remained almost unchanged for nearly fifty years. His acuteness, readiness, orderliness, and power of organization were as remarkable as his mechanical genius and inventive skill. He devoted all his attention to the special business before him, and would have won a high and honourable place in any other walk as well as that in which his lot was cast. From his very earliest years as an employer of labour he spared no cost or pains to benefit his workpeople to the utmost of his power. His great works were built on a scale and in a style to afford all possible convenience and comfort to the persons employed. More than thirty years ago he established a benevolent society among the workpeople, to which he subscribed liberally. As a master, or rather as a chief, he was respected and honoured by all. He had the rare sagacity to detect the special merit of each, to put each in his proper place, and to treat him with liberality. In his constant daily intercourse with his workpeople he was rarely familiar, but never austere ; and it is high praise to say that he seldom changed his officers, and never had a dispute with his workpeople in the whole course of his life." As regards the pen works, the same writer observes :—"They at present (1872) employ about 450 persons, the manufacture of pens reaches more than five tons per week, and the prices have been reduced from one shilling each to a few pence per gross—all the work of the active brain and skilful hand of one industrious and able man. Every visitor to Birmingham very properly holds that a visit to these works is both a duty and a pleasure. The courtesy of the attendants, the interest of the processes, the cleanly, orderly industry of the various rooms, the wonderful and delicate skill of the slender fingers and the ready hands, the millions of the little peaceful weapons fashioned for all parts of the globe, are a marvellous tribute to the genius, perseverance, and liberality of one of the most famous heroes of the arts of peace. All readers will be glad to know that Mr. Gillott's eldest son inherits his father's mechanical genius and generous spirit, and that the world-famous works are not likely to be closed to the public eyes."

It is not only, however, as a pen maker that Mr. Gillott deserves to be remembered. This record would be incomplete without mention of his great collection of pictures. The taste for art was developed early in life. So soon as he had money to spare, Mr. Gillott began to buy pictures. At first he was attracted by the works of the "old masters ;" and not unfrequently, we believe, these were acquired by a sort of barter : when money was not always available, he gave pens for pictures. By degrees, as Mr. Gillott became richer—and perhaps as his natural shrewdness taught him that the market for "old masters" follows the economical rule of demand and supply—he turned his attention to the formation of a collection of the works of the best modern English painters. Apart from business, this was the work of his life ; the collection constantly grew, both in quality and extent, until at last his house in the Westbourne Road, Edgbaston, and his residence at Stanmore, near London, were crowded with gems of English art. The Edgbaston house, to use a familiar phrase, was an exhibition in itself. Not only was every inch of wall space occupied in the three galleries built specially for the purpose, but the living rooms of the family, and even the bed-chambers, were adorned with pictures and drawings of surpassing interest ; while large numbers of other drawings of priceless beauty were stored away in folios. The great strength of Mr. Gillott's collection lay in Turners and Ettys —the last-named artist being a special friend of the collector. Besides these, however, he had rare examples—John Linnell, Collins, Muller, Maclise, Leslie, Mulready, Cox, Eastlake, Calcott, Webster, Wilkie, David Roberts, Frith, Hook, Poole, William Hunt, Faed, Nicol, Copley Fielding, Prout, and almost every English artist of note. He cared less for foreign artists, and even amongst our own he had no love for the Pre-Raphaelites ; none of their works were to be found in his collection. The two chief merits of Mr. Gillott as a collector were that he would have nothing poor or mean, and that he was sagacious enough to recognize excellence before the public had made up its mind as to a painter's rank. He was a persevering collector too. He would "mark" a picture and get it, even when the painter desired specially to keep it for himself. Many stories of this kind of honourable perseverance are told in regard to his relations with Turner, but we are bound to say that not a few of those current are apocryphal ; though Mr. Gillott, in his own quaint and pleasantly humorous way, would sometimes tell of desires realized and of difficulties overcome, when success appeared to be least probable. To his peculiar honour, in reference to Turner, it should be remembered that he bought when others doubted. His insight into character, and his intuitive knowledge of art, enabled him to foresee the approaching eminence of the great master of landscape. Thus it happened that a Birmingham manufacturer was one of the earliest to appreciate Turner, and to represent in one collection his development in every phase —long before the "Oxford Graduate" glorified his hero, and established his own fame as a critic and a writer, by his glowing panegyric in the "Modern Painters." We must not, however, linger upon this phase of Mr. Gillott's life. The sale of his collection—a lamentable dispersion of art treasures—is too recent to be forgotten by our readers. The enormous produce of the sale, £170,000, affords proof that art not only yields the highest pleasures, but "pays" in a commercial sense—for Mr. Gillott's pictures brought in all cases a large profit upon their purchased price.

A few personal "notes," with the help of the portrait we give elsewhere—a copy of the only one known to exist—will give the reader an idea of the man himself. For these notes we go back to the brief memoir already mentioned. "Mr. Gillott's figure was short, sturdy, square ; his hair and beard (for many years before his death) silvery and venerable ; his forehead broad, well rounded, high ; his eyes clear, humorous, and bright ; his expression pleasant and assuring ; his walk light, active, firm. His chief characteristics were remarkable quickness and accuracy of observation, wonderful shrewdness, common-sense, and frankness ; boldness, decision, and enterprise ; rare mechanical skill and constructive powers ; special talent for arrangement and organization ; and rapid and sound judgment on all matters which came before him. For many years his cheerful face was familiar at the Birmingham Theatre—nearly every evening for an hour or two—for he was very fond of theatrical performances, and invariably seated himself at the back of the 'third box,' where, with large knowledge and good taste, he joined his friends in remarks upon the performances. At the 'Hen and Chickens,' also (a well-known Birmingham hotel), smoking, according to his custom, the old-fashioned 'churchwarden,' he was always a welcome visitor, and readily joined in conversation with acquaintances or with chance visitors. While his manners were quiet and unostentatious, his frankness and decision were marked, and he made no secret of his opinions on political or social topics. His strong self-reliance—as of a man who had consciously fought his way to wealth and fame—remained characteristic, but his modesty of manner, and his habitual secretiveness about personal matters, kept him always in private life. Although much sought in 'society,' he preferred the simple pleasures of his home and the company of his immediate friends. In his own house his hospitality was princely though unpretending, and was unrestrained by merely conventional formalities ; while in his noble galleries he was a charming, courteous, and

instructive guide. His pictures, and his remarkable collections of violins by the 'great masters,' were indeed the pleasure and glory of his life. Until within about nine or ten days before his death failing eyesight was the only sign he gave of advancing age. On the day after Christmas Day, 1871, he entertained, as usual, some of his children and their friends, and expressed a hope of seeing them all again at Christmas, 1872. The next morning he felt unwell; a complication of pleurisy and bronchitis quickly reduced his strength, and on the 5th of January, 1872, the active frame and the busy brain sank quietly to their last rest."

We now come to a description of the processes involved in the manufacture of steel pens. The steel is obtained chiefly from Sheffield, where it is rolled into thin plates, which are usually cut into slips about four inches broad and three feet long. The pen maker has to prepare these strips by immersing them for some hours in a "pickle" composed of diluted sulphuric acid, which clears away the scales, and gives evenness to the surface of the metal. The steel is then rolled again to reduce its thickness to about the 160th part of an inch. Then the first process of manufacture begins. The strip steel is passed to a girl seated at a fly press fitted with dies and punches of the size and shape of the pen intended to be cut. As nearly as can be conveyed without the aid of diagrams, the following is a description of the press. It is taken from an interesting little work, "Illustrations of the Useful Arts," by Mr. C. Tomlinson (Myers and Co., Berners Street):—"The press acts much in the same way as a powerful, well-directed hammer, in giving a hard and unerring blow. Precision is attained by a slide whereby the punch is guided; force is given by a lever or fly, which by its revolution sends down the screw of the press. The body of the press is made very strong, and is fixed upon the base or bed. This is also of great strength, and is at right angles with the screw; the latter is coarse in its pitch, with a double or triple square thread. The upper part, or head of the press, is an iron lever, or 'fly,' with heavy cast-iron balls at each extremity. When put into motion this lever sends round the screw, which acts upon the punch, so that the entire momentum of the fly is expended upon the work to be punched or stamped, and the re-action causes a strong recoil of the screw. A handle descends from the lever, and by its means the operator can work the press with one hand while adjusting with the other the material to be punched. The screw is attached at its lower extremity to a square box, and this last is attached to the punch. Parallel with the punch is the bottom die or bed, kept in position by strong screws. A piece called the 'puller-off' prevents the sheet of metal which has been punched through from rising with the screw." So rapidly can the press be used and the blanks cut, that one girl will produce eight thousand blanks in a day. The blank thus cut is a flat piece of metal, shaped with a sharp point, like a pen, the steel being so placed that its fibres run in the direction of the length of the pen. The next process is to pierce the blank with a hole just above the top of the slit, so as to give elasticity to the pen. The blank is next annealed, or softened, by being enclosed in an iron box with tallow, and then placed for some time in a furnace or muffle, the contents of the box being red-heated, and then allowed to cool gradually. Next, the maker's name is punched upon the blank—again by the agency of the press. Until this process the blank has retained its original shape—a flat piece of steel. It is now "dished," or shaped, in the press; a die and a punch being fitted for this purpose, accurately fitting each other, and forming between them the shape of a pen. Another process of hardening follows; a number of pens are enclosed in an iron box, red-heated in a furnace, and then plunged into oil; the oil adhering to the metal is removed by agitation in circular barrels made of tin. This makes the pens brittle, and this has to be corrected by another process, that of tempering, effected by exposure to a gentle heat, which restores the toughness of the metal. By this time the pens have lost all their brightness, and have come to look like dull pieces of black iron. They have, therefore, to be cleaned or polished, which is effected by placing them in a revolving tin cylinder with sand, pounded crucible, or some other cutting substance. The cylinders employed are about nine inches in diameter and about three feet long. By the aid of machinery the cylinders are kept constantly in motion, up and down, backwards and forwards, until by rubbing against each other the pens are cleared from roughness and are brightened to the colour of polished steel. Another set of processes now begins—grinding and slitting. These are performed by girls with inconceivable rapidity. The nib is ground by picking up each pen with a pair of pliers, and applying it with a single touch to a rapidly revolving wheel coated with emery, first lengthwise and then across the nib. Then comes the slitting, which is done with the press. The descending screw has an exactly corresponding chisel cutter, which passes down with precise accuracy—the slit is made, and the pen is completed. Even yet, however, there is something more to be done—the colouring brown or blue. This is done by putting the pens into a revolving metal cylinder, under which is a charcoal stove, and removing them the instant the desired tint is imparted. Brilliancy is then given by immersing the pens in a solution of lac dissolved in naphtha, and after drying they are ready to go to the hands of women whose work it is to examine the new pens, throw out those which are defective, and count the rest and pack them into boxes for sale. To the reader this description may appear somewhat complex; but in reality, as observed in the pen factories, the operations are extremely simple. Owing to the perfection of the machinery and the skill of the workers, everything proceeds with amazing speed and with beautiful regularity—the whole place moving onwards like a vast machine.

The steel-pen trade has developed in a degree little short of marvellous. The merit of the first impetus is due to the late Mr. James Perry, who by wonderful energy, constant advertising, and the establishment of sale rooms and agents throughout the kingdom, literally forced the steel pen into use. Still, notwithstanding his efforts, it was found extremely difficult to conquer popular prejudice; but when success was finally attained, and the public began to find how useful and cheap an instrument was placed within their reach, the use of the new pens developed in a degree almost faster than the productive powers of the makers. Curious and interesting evidence of this is given in the volume on the "Hardware Districts." When the British Association first met in Birmingham, in 1839, steel pens were almost unknown. By the second visit of the Association, in 1849, the trade had become a leading industry of Birmingham—not fewer than twelve makers having established themselves, some of them on a large scale. So far as can be ascertained, there were in 1849 employed in the trade—12 masters, 300 men and boys, 1,500 women and girls, and machinery driven by engines of 300 horse-power. The number of pens made weekly was 65,000 gross; or about 6½ tons of steel was the quantity used each week. The value of the slip or ordinary pens was then from 6*d.* to 2*s.* per gross, and of barrel pens from 8*d.* to 12*s.* per gross. In 1865, when the British Association visited Birmingham for the third time, the following statistics of the pen trade were collected:—Masters, 12; men employed, 360; women and girls, 2,050; horse-power, 330; quantity of steel used weekly, 9½ to 10 tons; number of pens made weekly, 98,000 gross—or 14,120,000 separate pens! The value of the pens varied from 1½*d.* to 1*s.* per gross for "slips," and from 7*d.* to 12*s.* for barrel pens. The number of persons employed does not include those who make the paper and other boxes used for packing the pens. The large increase of make, as compared with the small increase in the number of persons, is due to the improvements in machinery in the interval, fewer "hands" being now able to turn out larger quantities of pens. The progress made in this direction is best indicated by the reduction in price. Thirty years ago pens were sold wholesale at 5*s.* per gross; now, pens as good, or better, may be had for 1½*d.* per gross. When it is remembered that each gross requires 144 pieces of steel to go through at least twelve processes in the course of manufacture, the fact that 144 complete pens can be sold for 1½*d.*, after providing for material, paying wages to workpeople, and leaving a profit to the maker, is a convincing proof of the results attainable by the exercise of mechanical ingenuity, assisted by economical division of labour.

The condition of the workpeople employed in pen-making is satisfactory, in consequence of the large and lofty rooms in which the work is generally done, and of the discipline necessary to the regular conduct of the business. The wages of girls vary from 5*s.* to 12*s.*, some of the younger ones earning only 2*s.* 6*d.* to 3*s.* 6*d.*, while a few of the older and more skilful women earn from 15*s.* to 20*s.* per week. The ordinary men earn from 18*s.* to 20*s.*; the boys vary from 6*s.* to 16*s.*; the skilled men from 30*s.* to 80*s.*; and some—chiefly the best tool-makers—get as much as 90*s.* or 100*s.* per week. The hours of labour are from 52½ to 57 per week, all beyond being reckoned as overtime, and the Saturday half-holiday being generally conceded. The trade, so far as Great Britain is concerned, is almost entirely, if not entirely, confined to Birmingham. There are six or seven factories in France, producing about 50,000 gross per week; in Germany there are two or three factories with small production; and in the United States there are four, producing about 10,000 gross weekly. The French and American factories were due to the high rates of duty imposed by those countries upon English pens; and most of them were started by the aid of English workmen, tempted by high wages.

To describe the varieties and curiosities of the pen trade, or to enumerate the patents taken out within the last thirty years, would require a volume; and this, if prepared with competent knowledge, would form a record in its interest second to none in the history of manufacturing skill and commercial enterprise. Within our limits we can but note, as indicating variety, that the patterns of pens and their markings are literally innumerable;

one manufacturer, for instance, has more than 500 "marks" made for buyers who require their own names or devices to be stamped upon the pens—while the varieties of shape, size, slit, and colour change with each passing whim, each fancied improvement, and the natural desire to stimulate demand by novelty, or to meet the necessities of different kinds of customers. Through all these conditions, however, the cheap and familiar "slip" and the more costly "barrel" hold their ground; and upon the forms and qualities of these, as produced by the best makers, it seems difficult, if not impossible, to conceive that any distinct improvement can be made. Pens of other kinds than steel are beyond our limits, or much might be said of them, for pens have been, and still are made of all kinds of material—gold, silver, copper, bone, tortoiseshell, and even precious stones, being used as "nibs." For common use, however, steel surpasses all of them. To adopt a well-known American phrase, "In the world of pens, Steel is King;" and we may add that his throne is set up in Birmingham.

[Those who may wish to see the patents taken out for improvements in steel and other pens, will find them collected in a volume lately issued by the Commissioners of Patents, and entitled "Abridgments of Specifications relating to Writing Instruments and Materials. A.D. 1635-1866." The volume contains much curious information on all inventions relating to writing.]

TIMBER TRUSSES AND GIRDERS.

THERE are many who are in the habit of regarding timber as almost an obsolete constructive material in this country, an idea which we shall point out is fraught with mischievous consequences to any young engineer who may be sufficiently unfortunate to entertain it. It cannot be denied, that in the case of permanent structures, especially when the examples are on a scale of some magnitude, timber has been to a very considerable extent superseded by the modern constructive material par excellence—iron. Yet for structures of a temporary character, and for a particular class of permanent work, timber still continues to be employed, and will continue, so long as there is a vestige in the world of any "primeval forest" whence it can be obtained. To each description of material belongs in a great measure its own proper sphere of utility and application. It is true that for some purposes two or more materials are equally well adapted, but yet there remains for each one, some especial class of work for which it is better suited than others.

In consequence of the fact—for it is a fact, notwithstanding instances to the contrary—that iron has greatly superseded timber at home in the field of engineering construction, young engineers and pupils frequently imagine, that they need not concern themselves about the details of timber and wood-work. Many consider it quite unnecessary to make themselves acquainted with the different methods of joining together the various parts of a timber truss or frame. Some indulge in the happy idea, that the parts will arrange themselves by some "fortuitous concourse of atoms" or method of their own, and others are completely satisfied that "the carpenter will do it." At any rate, whatever may be the precise manner in which they relieve themselves of their responsibility, the conclusion arrived at is the same, and the consequence also is the same, which is that they remain ignorant of details which it ought to be their first study to master, and the want of acquaintance with which will at some future time be seriously and severely felt. It is frequently not until young engineers are sent abroad, that they begin to experience the grievous mistake they committed, in not availing themselves of every opportunity, of rendering themselves familiar with the details of carpentry on a large scale. Good foremen are scarce everywhere, and are often not to be had at any price in foreign countries; so that the engineer in charge of works has to supervise everything, and, moreover, show the men the exact manner in which any particular detail is to be worked out.

What happens if he is unable to do this, or, at any rate, unable to do it as it ought to be done? Somehow or other the work must be got on with, rightly or wrongly. He finds himself in the unfortunate position in which one of his military *confrères* was placed in India some few years back. In consequence of the wholesale falling down and collapsing of some Government buildings, a committee was appointed to inquire into the whole matter. After a thorough and searching investigation, they gave in their report, which, among other strong animadversions upon the manner in which the whole of the work had been carried out, contained the remark that the method by which the timbers were scarfed and joined together, betrayed the most profound ignorance of the commonest details of carpentry on the part of the engineer in charge. We are not aware that so sweeping a condemnation of professional incapacity, has ever been so publicly asserted of any of our civil brethren.

The particular description of timber design that it may be the best to employ, will depend upon two principal conditions. One is the span of the structure, if a bridge or roof, and the other the size of the timber that can be procured, with reference to both the length and the scantling, but especially the former. So far as the scantling, or, in other words, the sectional area of the material required, is concerned, it is an easy matter to build it up of two, three, or more beams, without necessitating any great amount of jointing or extra workmanship. But it is when beams come to be joined in the direction of their length, that the joints are troublesome and expensive, and the strength of the beam suffers the most. It can therefore be readily perceived that a description of truss, or framed design, which will answer admirably when long timbers can be procured with facility, will be far from proving an economical design when only short lengths are available for its construction. What is the particular object in employing a truss instead of a plain rectangular beam? It will be found that the chief reason is not, except when large spans are reached, for the purpose of imparting strength but stiffness to the structure. A single beam, twenty feet in length, all in one piece, is stronger and very much stiffer than the same beam scarfed in two places; and therefore when long timbers can be obtained, the simplest description of all bridges, namely, that of a single beam laid on two supports, can be used in situations in which a truss would be required were only short timbers at hand. But even with the longest timbers procurable, the limit of their application is soon arrived at, more especially as the bending moment, or tendency to sag, increases with their length. The object of the employment of all trussed beams is, briefly, to eliminate all bending moments, and to convert the cause of them—that is, transverse strain—into strains of tension and compression, which act only in the direction of the length of the several members which, in the aggregate, build up the compound structure. This condition, in a properly designed truss, is carried out from the elementary form, used in the ordinary gantries or wharf travellers, to the most complicated designs of the arch and girder, examples of which are to be met with on the American railways. A timber truss may be regarded, generally, as consisting of upper and lower beams placed at a certain vertical distance apart, and connected at intervals by shorter timbers, which may be either vertical or inclined to the horizon at some one convenient angle, or both. The primary object, the elimination of all transverse strain on the upper and lower members, is thus accomplished by the number of points at which they are supported throughout their entire length; and they are thus cut up, as it were, into a number of short lengths, in each of which the bending moment is reduced practically to zero. When the truss assumes large proportions, the short timbers, vertical and diagonal, become sufficiently long to be themselves liable to bend or sag, and it is necessary to divide them also into shorter lengths in order to obviate that tendency. When all these members individually have been secured from flexure, and been rendered liable to be acted on by strains only in the direction of their length, there yet remains the rigidity of the whole combined structure to be ensured, which depends upon the proportions of the various parts, the ratio of depth to span, and the character of the design, more especially with reference to the particular kind of duty it has to discharge. A truss, well adapted to a single load at the centre, is entirely unsuited to the same load uniformly distributed over it; and again, a design which will answer well for the latter description of load is unsuited, in some of its details, to the same load which is constantly shifting its position on the truss. It is especially requisite in the construction of timber bridges that these points should be carefully attended to.

The commonest example in practice of a trussed frame is the trapezoidal, and it is an economical form for spans not exceeding forty feet. It can be used in both positions, either with the end bars as struts, or as ties. If the load is to be on the top, the bars will be struts, and the frame assumes the shape of the principal of a queen-post roof. If the load is placed on the bottom, and the truss inverted, the struts become ties. Briefly, in the position of a roof principal the end bars are struts, and in that of a gantry they are ties, irrespective of the manner of loading. In scarfing the tie-beam in two places for this kind of truss, on the supposition that the load is on the tie-beam, it is a common practice to make the scarf at the points of connection with the vertical and diagonal bars with the tie-beam, so that the whole of the connections of the several members occur at that point.

This is objectionable on the score of the great local weakness that must arise in consequence. The omission of cross-bracing, which should always be introduced in the centre part of this truss, is of very frequent occurrence. A modification of this truss, in which the tie-beam is dispensed with, and the end struts bear against the abutments, is a useful form when only short timbers can be procured and it is desirable to adhere strictly to economy. When this form is adopted, care must be taken to stiffen the bridge laterally by the use of diagonal bracing between the separate trusses. For examples of timber trusses on a large scale we must look to America. The lattice principle was, in the early days of railways, very much employed there for spans of about one hundred feet, but it did not meet with that success, when larger spans and heavy loads had to be provided for, which has attended similar examples constructed of iron in this country. A well-known American truss is that of Howe, which consists of horizontal upper and lower members, vertical iron ties, and diagonal wooden braces. This truss is counterbraced, and it was supposed that by keying it up, the violence of the shock of a passing train might cause very little or no additional strain upon it. This supposition proved, as might have been expected, altogether erroneous; and for spans exceeding one hundred and fifty feet, this description of truss soon ceased to be employed. Another form, which was very much used for spans between a hundred and fifty and two hundred feet, was the "Improved Howe Truss," which was simply the old type with the addition of arches. The object endeavoured to be gained by means of this combination was, that as neither truss nor the arch was strong enough in itself to bear the load, they might be able to do so conjointly. The theory was, that each member would do its duty independently of the other, and that by dividing the work between them, the whole would be performed satisfactorily. Although experience has shown that this nice adjustment is impossible, yet for a time these trusses did their duty very well. But no structure, the design of which is contrary to sound theoretical principles, can ever last, and so it proved with the bridges in question. It was not long before the original camber given to the lower member was destroyed, and the tie-beam sagged below the horizontal line. The number of joints and connections, at which sooner or later decay made its appearance, greatly contributed to the whole structure speedily becoming rickety and unsafe. The theory of the combination of the two systems is defective. If the two should ever be employed together, the proper plan to adopt, is to depend upon the arch as constituting the bridge proper, and add a light truss for the purpose of stiffening the roadway. In other words, the strength of the bridge should lie in the arch, and the stiffness in the truss. A modification of the bow-string principle makes a good timber truss, but in it, as well as in all those examples on a large scale, the use of iron tie-rods, either vertical or diagonal, is indispensable. Hence, in all these trusses there are three sets of braces, where there are only needed really a couple, theoretically. The same remark holds good for similar trusses built of iron.

The durability of a timber bridge in America is generally put at from twelve to fifteen years; but in the present day, with the increased weight of locomotives, it is very doubtful if they would last any longer than ten years. By the term durability we do not mean the mere existence of the bridge, but its existence in a thoroughly serviceable and useful condition. When a bridge reaches such a state of decay that it has to be strutted, braced, and propped up in a manner totally at variance with the original design, we consider that the original structure has ceased to exist, and that its term of durability has expired. Take Battersea Bridge as an example, which is only kept from falling bodily into the Thames, by obstructing the greater portion of the waterway beneath by piles and scaffolding. If it were burnt or pulled down, or otherwise destroyed next year, it would be obviously a totally false datum on which to base the durability of similar timber structures, to assert that it lasted from the date of its building to the year 1874. There are three causes chiefly operating to rapidly destroy all timber structures which are exposed to sudden and violent strains. The one is the natural perishable nature of the material, the second the number of joints required, and the third the nature of those joints. It is evident that it is quite impossible to secure the joints and connection of the several members of a timber truss, in so complete and rigid a manner as in those constructed of iron. There is no such thing as riveting wood, and no preventive nor cure for shrinkage. It has been proved that the joints of the web and flanges of iron girders, which were made by tightly-fitting pins, have become loosened by the continual vibration of passing trains. In addition to this loosening effect, which must take place with greater force on the joints of timber bridges, there is the shrinkage which allows of the introduction of wet, and the subsequent decay of the timber in the neighbourhood of the joint. These causes combined soon lead to the deterioration of the structure. Special precautions can be taken to mitigate these evils, although they can never be altogether removed. The best form of joint should be used, and if the sides of the truss were carefully sheeted in with weather-boarding, the penetration of wet might be prevented. The adoption of precautions of this kind and the roofing in of timber bridges, have been found to add several years to the life of these structures in America. In all new countries whose resources are undeveloped, and means of communication very restricted, it is the duty of the engineer to avail himself to the utmost of all the constructive materials indigenous to the locality. Materials and workmanship are the two components of all structures; and superior excellence or abundance in the one can, to a certain extent, compensate for inferiority or deficiency in the other. In new countries materials are frequently abundant, but good workmanship and skilled labour scarce and inferior. The engineer must therefore endeavour to use as much of the former and need as little of the latter as possible. Briefly, quantity must take the "pas" of quality.

THE SILK INDUSTRIES OF ITALY.

(*From an Italian Correspondent.*)

Maleo, 15*th April.*

RAW SILK.—II.

IT is a pretty sight on a bright sunshiny day to see upwards of one hundred women, seated in two long rows, spinning; some young, some old—some with Madonna heads—some not beautiful, but most of them intelligent-looking, their dark eyes and hair rendered more attractive by the coloured kerchief picturesquely folded round head or shoulders. The quick motion of the asps, the gleaming of the rich silk, exhilarate one. Ever and anon the women take up the chorus of a song, led by the best soprano, or at vesper sing the Ave Maria, some chanting the melody, others the accompaniment. This is a picture that might probably strike the stranger with admiration if he visited our "Filanda," a large building about twice as long as it is wide, lying from east to west, so as to enjoy as much sunshine as possible; for silk, like the silkworm, requires air, light, and warmth.

The process of spinning, *i.e.* detaching the thread from the cocoon, and winding it upon the reel or wheel, is simple. The *spinning girl* has her seat before a large basin or sink, with a tap for cold water on the one side, for hot water on the other. The greatest judgment and experience are required as to the quality of the water and its temperament. It must neither be hard nor dirty, and is often softened by certain chemical mixtures, sometimes by the crushed bodies of the silkworms themselves. Again, the silkworm never goes round the cocoon in a straight line, but places little deposits here and there in little coils, similar to so many eights (8), and the whole thread is covered by a down, which is microscopically like that on a peach, covered, however, by innumerable little threads branching out. Now, from both these causes, it is most essential that the water should not dissolve the thread too rapidly, though if there be any delay it becomes brittle. From the basket at her feet the girl takes a handful of cocoons, and having tempered the boiling water to 75° R., she allows them to soak a little, and then rubs them gently with a soft scrubbing-brush. The warm water has naturally dissolved the gum of the cocoon, and the threads adhere to the brush. She takes them off and attaches them to a hook before her. The single thread, as it issues from the worm's mouth, is of course too fragile for weaving purposes, and from four to seven threads are necessary. The woman, therefore, takes as many cocoons as she wants threads—let us say four; from the mass on the hook before her she twists four threads roughly into one, and introduces it into the hole of a little disc of porcelain attached horizontally to the opposite edge of the basin. Perpendicular to the disc rises an iron rod, bearing at about three inches from its base a little wheel with glass spokes, six inches above this is a similar wheel, and, on a horizontal bar which supports the rods, a hook of porcelain. Porcelain, glass, and similar hard polished materials are used, because they preserve the gloss of the silk, and are not affected by its passage.

The thread is carried from the disc to the upper wheel and thence to the lower, and thus the threads, kept together by the disc, are further rounded into one by the little wheels, which their passage causes to revolve rapidly. Around the piece of thread, stretched from wheel to wheel, the spinner twists the end in her hand. In this twist resides the remedy against knots (as

I call the little eights) and down, and its use is obvious. It smooths the down and prevents the passage of knots and other impurities. The twist must be very long and close, and it then constitutes an effective barrier, so that the thread of the guilty cocoon is unable to pass breaks. If the twist, on the contrary, is short, everything passes like smuggled goods before the nose of an indulgent *douanier*. The women, as a rule indulgent to excess, require to be constantly watched by the overseer, whose melancholy duty it is to walk up and down all day; and the women are kindly, because—because it saves them trouble, for every time the thread breaks they must supply a new one. This they do with incredible speed and dexterity. The eye cannot follow their hand, which takes a thread from the mass and throws its extremity around those under the disc, as the Mexican throws his lasso on the neck of the fleeing horse.

We follow the woman, who, having relieved the cocoons and set them at work in the manner described, passes the thread over the hook of porcelain, which keeps it straight, and dexterously throws it on to the wheel or asp behind her, which eagerly seizes it and spins it round at the rate of eighty to one hundred revolutions a minute, and even more.

This wheel is turned by machinery, but can be stopped at will by the woman. It is not in reality a wheel, but four or five very thin, deep pieces of wood, supported by the necessary spokes, placed at the distance of one and a-half feet from each other, and taking root in a central wooden cylinder. If the silk thread were led from the porcelain hook straight to the asp, it would conglomerate in one spot, when, if damp, it would remain damp, and it would further be impossible to find the uppermost thread. This is very ingeniously obviated. Before being thrown on the asp the thread passes through another hook; this hook, in communication with the asp, moves, when the latter turns in a horizontal plane like a pendulum, thus distributing the thread evenly over a space of three to four inches, and causing the thread at each revolution of the wheel to cross the preceding layer.

When the cocoons have all come under the disc, rebelled and again set themselves afloat, they are taken out, a new handful is gently brushed, and the rebels submitted to a second operation.

The used cocoons (which assume a greyish colour) are taken out. I have in my explanation shown how one thread is spun; in reality two or three are sent up the asp contemporaneously; when the spinner has to watch twelve cocoons instead of four she takes a lively interest in them, now bidding them make haste and not break, anon abusing them roundly when they float off or otherwise misbehave.

When three threads are spun, the asp turns more slowly to give the spinner time to supply threads, and in many establishments the cocoons are prepared by one woman and spun by another. This is more advantageous, as it saves time and secures closer attention by the division of labour.

Nothing is lost in a Filanda; the gathered threads are not thrown away, neither are the cocoons wasted when they have been worked to a transparency which allows the chrysalis to be seen. The threads are cleansed by girls; the mass is drawn asunder, and assumes its threadlike appearance, and the "Struse" as they are called, are exposed to the sun to dry. They are then packed and sold.

If of good quality, these "spoils" of the cocoon fetch from 6*s.* to 8*s.* per lb., and manufacturers weave them into silk handkerchiefs, neckties, and similar objects; and so perfect is their manipulation, that, although an inferior silk, as I have said, they show to the best advantage, and often what you proudly wear round the neck, my dear sir, is not the richest of silk stuffs.

The last covering of the humble chrysalis itself goes to make stuff. It is washed, pressed and dried. Human ingenuity, aided by machinery resembling a comb, combs down the silk it contains and works it. And thus nothing is lost, the dirty water in the spinner's basin being used to wash the chrysalis cone. The body itself is used as manure.

The silk is now spun; at twelve and eight o'clock the women carry the product of their toil to the silkroom, in the shape of two or three yarns of silk, which if cut through would measure 6 to 7 ft. in length. They hang these circles of silk carefully on pegs, with numbers corresponding to the number of spinners; each has her peg. The whole apartment is set aside, as it were, for the silk; none dwell in it except the young girl in whose appropriate charge is the precious booty of the silk-worm; few enter it, unless "strictly on business." In this sanctum the work of the several women is carefully examined and its merits tested. A few words will suffice to explain how this is done, for if the reader has followed me hitherto he must know what the qualities and defects of silk are.

I have spoken of the exceeding fineness of the silk-thread; it requires a very experienced eye to note shades of thickness, and the touch itself, which is more relied on than the eye, is not absolutely trustworthy. Therefore, the inexorable standard of weight is appealed to—a weight delicate as silk requires it—the "denier," equal in weight to a grain of corn, on the decimal system half a decigramme, which in the hand is imperceptible.

The average weight of a thread of silk of the length of 400 "aunes" (ells) is known to be $2\frac{1}{4}$ to $3\frac{1}{2}$ deniers, according to the coarseness of the cocoon; so that a thread of three cocoons will be three times, one of four, four times that weight. The girl proceeds to take 400 ells of silk from the yarn. For this purpose she stretches it on four pegs which fit respectively into the arms of a wooden cross. She then seeks the uppermost thread, and carries it on to a little asp turned by hand, which causes a clockwork to strike at every 100 revolutions, each revolution measuring an ell.

Whilst with one hand the maid turns the handle of the little wheel, with the other she holds the passing thread; and her experienced touch detects every marked irregularity in thickness, whilst her eye carefully examines the gathering thread to see whether an insufficient twist has allowed the down or other impurities to pass. Ever and anon the thread breaks on its passage; if it breaks often, the little assayer knows by its brittleness that it was spun in tepid water. All these remarks are noted against the respective numbers.

The proofs, as they are called, are suspended on a board, number by number, to await the final examination of the manager.

He weighs these proofs on a delicate little balance similar to what is used for letters. If the proofs are above or below the prescribed number of deniers, called the "title," an irregular thread has been spun, either with more or less than the right number of cocoons. Thus the women are checked as to the title. But a farther check is exercised. The silk itself is examined by the manager and weighed.

I have said that to each woman is measured out a given quantity of cocoons, the return of which in silk is exactly known—roughly stated, a fifth of the weight.

When the manufacturer buys the cocoon, he tries it, as I have said; and the price he pays is based on the silk he will obtain. If then he calculates, say, two of rough thread, two of useless matter, and one of silk, and the woman by rough handling of the brush reduces the silk to half, it is of course a serious loss. By weighing the yarn it is known precisely how much silk has been obtained.

The silk having passed the ordeal, is trimmed and folded in a manner difficult to explain.

The hand is passed into the yarn; the left hand forms the upper end into a loop by pressing the upper surface into the palm with the thumb; the right hand twists the silk until the yarn has become in appearance a rope; the end of the rope is passed twice into the loop, the loop tightened round the knot thus formed, and the yarn is ready for sale, if sold "raw," as silk not worked is called. It is sold of course according to quality, but as the finer qualities have usually a finer thread, silk is known in commerce by its weight of proofs, and ranges from 9-11 deniers the 400 ells to 40-45.

When silk is worked into two or three threads, the number of deniers of course augment accordingly. A. S.

BLOWING-IN A BLAST-FURNACE.

THERE has always been a certain amount of mystery, and yet one really scarcely knows why, attached to the operation named above, and which we are about to describe. As a general rule—at all events until later years—the practical management of blast-furnaces has been intrusted to men who had risen, as it were, from the ranks, having in most cases been originally founders, casters, or even cinder fillers, and who, although producing sometimes very excellent results, were utterly ignorant of the chemical principles of the operations they were conducting, and worked rather by the rule of thumb than any other. This state of things naturally produced a certain reticence on their part, a belief perhaps that they possessed some invaluable secret method of treating their furnaces, and certainly to our own knowledge an unwillingness to give, even to their employers, more information as to the burdens, pressure of blast, &c. &c., than was actually made compulsory on them. Indeed, on this point we recollect one very successful furnace manager in South Wales who persistently refused to give in at the office anything more than the average burden of the week. Any details of intermediate changes were always carefully withheld, or, as he liked to express it, he preferred "to throw the things together,"

which simply meant giving totals without particulars. Things are certainly very much changed since then, and the theory of the blast-furnace has formed the subject of extensive and very accurate investigation at the hands of such scientific men as Ure, Bauerman, Lothian Bell, &c. &c.

The mere operation of blowing-in—*i. e.* starting smelting operations in a blast-furnace, has not, we think, however, been very frequently described; and it is to that process of iron metallurgy we devote the present article. Presuming that we have our furnace stack built and completely fitted according to the designs decided upon, the first and most necessary proceeding in commencing operations is to get it well and thoroughly dried, any dampness remaining about the hearth being almost sure to produce a setting of the iron there, and probably no end of trouble and labour in cutting in at tapping times; whilst if the upper part be not also dry there will be an extra risk of scaffolding, and possibly a tendency, on the heat rising to working point, to a cracking and opening of the masonry, attended of course by an escape of gas and other inconveniences. On the first lighting of a fire on the hearth, for which any fuel will do, we have generally been in the habit ourselves of stopping up the tuyere arches with fire-clay, leaving the setting of the tuyeres themselves until it was determined to go on with the regular filling—this equally with coal, coke, or charcoal. We have found it advisable to fill up in the first instance to the full capacity of the furnace with fuel alone, and then, after placing the tuyeres, to draw on a weak pillar of blast. With charcoal furnaces a pressure of from a quarter to half a pound to the inch will be found sufficient, but with coke or coal a somewhat stronger pillar will probably be found desirable. The result of this will be the gradual formation in the hearth of a certain quantity of clinker and ashes, which should be periodically removed by forming a scaffold of ringer bars over the top of the dam-plate, which, supporting the superincumbent fuel, enables the furnace men thoroughly to clear out from the breast the whole of the hearth; and we think it an exceedingly good plan to allow a portion of the blast flame to escape through the tapping-hole — of course only until the first of the iron reaches the hearth—as it is thereby thoroughly heated, and any tendency to chill the metal or cause it to set is there prevented. Once certain that the hearth is thoroughly heated, the ore and limestone charges may be commenced; although we believe that in some instances these are filled whenever the blast is drawn on, the manager trusting of course to the quantity of fuel already in the furnace being sufficient for its perfect drying and preparation for the descent of the iron. With charcoal-furnaces there is but little difficulty at this point, but stonecoal and coke require great care to prevent adhesion and the consequent scaffolding; indeed bituminous coal will sometimes bake into large masses and cakes through which it is absolutely impossible that any air can pass; combustion is hence necessarily checked, and these masses have frequently, on their reaching the timp to be broken up by means of ringers and hand-bars and dragged out over the dam-plate. Another plan, however, is to put on a proportion in each charge of old castings or scrap pig-iron, which of course comes down very fluid and hot, and fairly eats through and breaks away any scaffolds that may have formed. A certain amount of anxiety usually attaches to the earlier casts from a newly blown-in blast-furnace, not only as regards the quality of the metal which may result, but also for the difficulty which sometimes arises at these stages, resulting generally from the want of sufficient heat, and the consequent setting or chilling of the iron as it reaches the hearth in getting the tapping-bar driven in. We have seen in cases of this sort a quantity of charcoal piled in front of the tap-hole, and by leading a small jet of blast round to it from the tuyere pipe, such an intensity of heat produced as readily to melt away any obstruction. After, however, say a week's quiet work at moderate charges, should all go well, the pig—grey or good healthy white—and the cinder well separated and running freely, the burden may be put up to its full weight, and in, say, three weeks the furnace ought to reach the proper out-turn. How immensely this has been increased of late may be gathered from the fact that some twenty years ago 200 tons of forge pig-iron per week were considered in the South Wales district a more than average production; whilst at some American works, notably those at Carondolet, between 400 and 500 tons of pig are regularly run out every week, and the proprietors anticipate, from some new stacks being erected, a large increase even on this. At these works, too, another not unimportant measure of economy has been taken. It is well known to all practical men that the points at which a blast-furnace first commences to wear out are those of the zone, say about two feet in height, which lies immediately above the tuyeres, and to check this tendency water-backs or jackets of wrought or cast-iron, with water-tight compartments running through them, and kept constantly filled with water, are placed in the exterior walls, and this arrangement is found to check or modify the destruction of the fire-brick lining. We have ourselves seen something similar to this tried in the shape of water boshes placed immediately above the tuyeres, with the effect generally, however, of lowering the quality of the iron produced. In a paper such as the present we cannot, of course, enter into the varied question of hot or cold-blast, character and position of tuyeres, &c., but we may perhaps in conclusion say that our experience certainly goes to prove, whatever may be its effect on quality, that hot-blast vastly facilitates the operation we have attempted to describe, *i. e.* "blowing-in."

THE PATENT STEAM NON-RADIATING ENGINE.

Ten-horse power nominal; 100-horse power indicated.

MESSRS. MOY AND SHILL, INVENTORS; DESIGNED BY N. P. BURGH, ESQ.

THE illustrations on the facing page represent a novel invention, as a combination, arranged expressly for the economy of fuel, which is successfully accomplished from the fact that no loss of heat in the steam occurs during its working, because the cylinders are enclosed by a casing having tubes projecting from it (which are actually the boiler), under which the fire is situated, and, therefore, obviously the casing is also surrounded by caloric; and thus the heat absorbed from the coal is not *lost* by radiation—as now the common practice—but is really *worked* out in the cylinder.

There is much to be considered in this matter, because when we remember that 90 per cent. of the fuel used in boilers is wasted by radiation and imperfect combustion, and the price of coals is at the highest figure yet known, any safe means of economizing the fuel, combined with the proper working of the steam, must be advantageous, and indeed an advance commercially as well as scientifically.

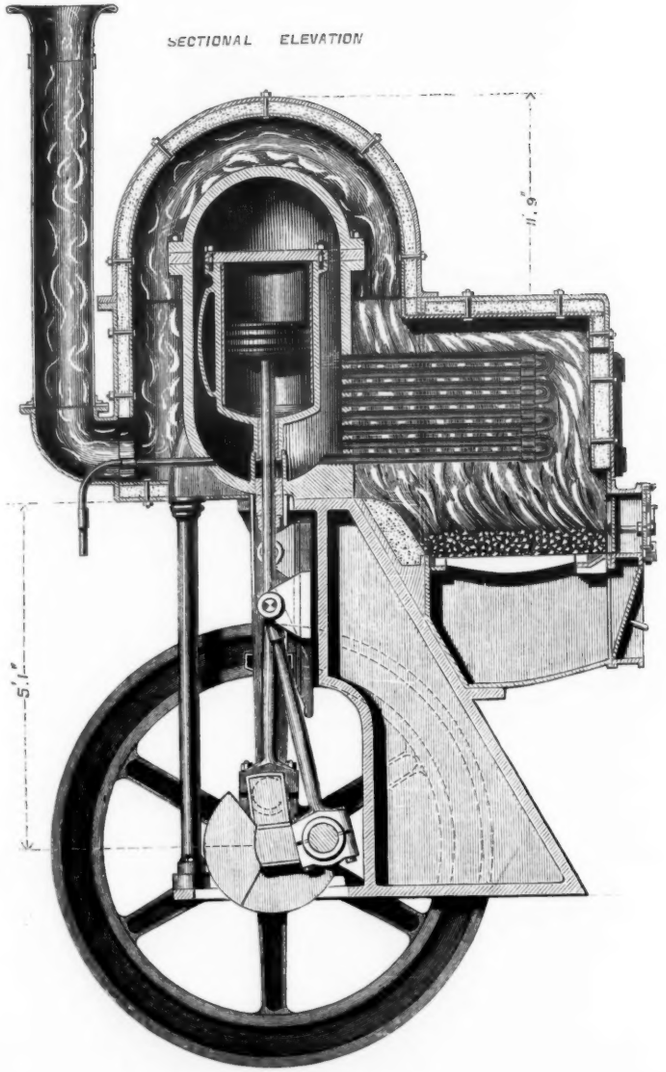
The "working of steam" requires an explanation, because it is not generally appreciated that steam is similar to all art productions, inasmuch as it can be made bad or good, and worked also in that way; for it too often occurs that a boiler is of such wrong proportions that the steam is generated in a saturated form, and thus the liquefaction reduces the power of the heat proportionately, it being certain that the power of heat in steam has its limit in proportion to the quantity of water and air. As, for example, let us suppose steam from a boiler that is priming, and we have the fact that the speed of the engine is reduced, not because the pressure is reduced, but rather because the water *thickens* the steam, and thus increases the friction of its passing. Again, but in an opposite way, let us suppose dry superheated steam, and we have the fact that there is no power gained above a certain temperature proper for the steam, while the working surfaces are injured by the steam cutting them.

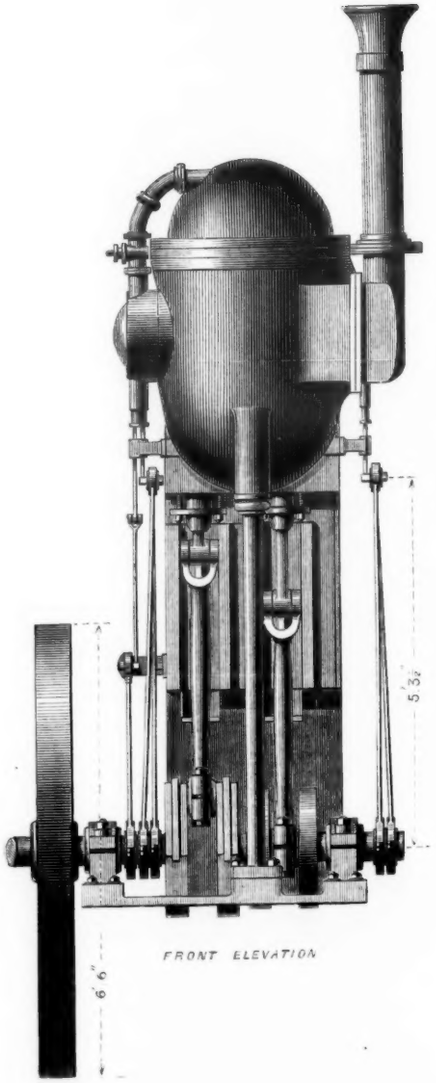
Now, from these two facts—which are pretty well known amongst the leading members of the profession—we gather that if steam can be made in a proper form there must be an advantage over the present methods, and we believe Messrs. Moy and Shill have arrived at it, because their working model, or rather little engine—now at St. Michael's House, Cornhill—fully proves it, by steam being raised from feed water of 50 degrees Fah. to 100 lbs. on the square inch in two minutes and a half; the engine running at 1,000 revolutions per minute, and only two small jets of gas being used.

The illustrations we have given are for a larger engine and on the compound principle, the steam at 200 lbs. on the square inch first entering the small cylinder, and then finishing its duty in the large cylinder, thence escaping to the atmosphere; but with marine engines a surface condenser will be used, and the feed water returned in the shape of condensed steam at a temperature of 212 degrees Fah.

The action of the generation of steam in the tubes is that the fire operates on the lower tube—of the syphon—mostly, and the upper tube is a medium for it to pass into the casing, and up through the water therein into the space above, from which it is used in the cylinders; and as the entire structure is surrounded by the heated gases, radiation is avoided.

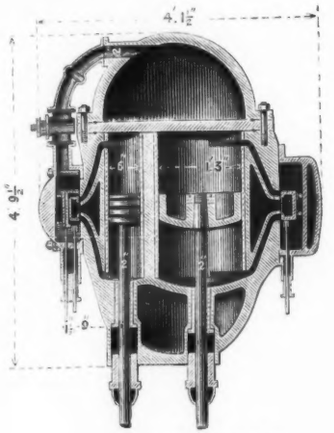
SECTIONAL ELEVATION





FRONT ELEVATION

SECTIONAL ELEVATION OF CYLINDERS



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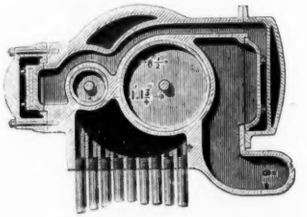

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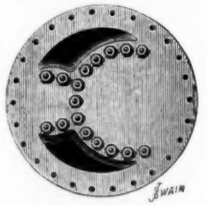


J. WAIN

THE HOUSE OF STROGONOFF, THE CONQUEST OF SIBERIA, AND THE RUSSIAN FUR AND TEA TRADE.

1. Introductory.

THE history of the family who opened up to Russia and the West of Europe the immense country lying on the farther side of that mountain chain, viz., Siberia, has not been treated of in any English publication that we know of. And as the conquest and colonization of Siberia were the necessary conditions for the foundation of its enormous fur and tea trade, the theme is one eminently suited to our pages.

Siberia, the largest country in the world, extends from the Ural to Behring's Straits. Its actual dimensions cannot accurately be stated, for its northern coasts are in the ice-bound Polar Seas, and its southern frontier advances elastically towards the core of inner Asia, towards Thibet and Afghanistan. When the Russians first took possession of it it must have been almost a desert, for even now, after 300 years, during which Russia has done so much for Siberia, it has not 5,000,000 of inhabitants. And this scanty population is very unequally distributed, consisting chiefly of Russians and Mongolians. It is settled mostly along the principal high roads, rivers, and in the milder south and west, leaving the north and east almost a desert. Everything connected with this country appeared terrible and repulsive; eternal snow covered the ground, and on the lonely, far-stretching tundras, or snow-covered heaths, with unsteady, marshy ground, even in summer nothing was seen but the mighty herds of reindeers, pursued by swarms of bloodthirsty mosquitos of the north. Wild nomadic tribes formed the only human population. Yet Nature had not treated the country in so harsh a manner in every direction; in the south and south-west there are fertile and rich tracts of land, with an almost Italian climate, capable of supporting a numerous population, when once they shall have been colonized by industrious settlers. There the corn ripens abundantly, cattle-rearing might be carried to an almost unlimited extent, and even the climate might be softened by the industry of the experienced agriculturist.

And independently of the products of agricultural labour, for the shipment of which the gigantic streams of the country offer great facilities, Siberia offers great mineral treasures to the seekers after them. Throughout its mountain ranges gold, platina, iron, graphite, lead, copper, and silver abound, and form some of the most important products of the country, which we shall discuss by-and-by. But not they first lured the Russian towards the East, and led to the conquest of the country; no, the attraction was apparently a much meaner one—an animal, not larger than the marten of Europe—the sable—led a bold robber with a gang of adherents across the Ural, and in a few years he, like Cortes to Charles V., presented to the Czar a mighty empire, which he had conquered in an incredibly short space of time.

2. The Strogonoffs and the Conquest of Siberia.

Seated on the throne of the rulers of Russia, in the Kremlin at Moscow, in the middle of the sixteenth century, was Ivan II. Vatiljewitsch, the second of the Russian princes that bore the title of Czar. Under him, who is known in history only as the "Cruel" or "Terrible," modern Russia was consolidated, and threw off the last remains of Mongolian supremacy. Yet this bloodthirsty tyrant did more than many others for the civilization of his semi-barbarous people. He invited foreign, chiefly German, artists, savants, and artizans, to Russia; for he saw that only by the introduction of Western culture his own country could be raised to an equality with other European States. The first Russian printing-office was established in his reign, and a fortunate accident was the foundation of commercial intercourse with England. In the middle of the sixteenth century English goods could only be introduced into continental markets at very low prices. Manufacturers, therefore, sought for new outlets; and an expedition of three vessels, commanded by Sir Hugh Willoughby, sailed in 1553 from the Thames to find a northern route to China and India. But two of the vessels were lost with all hands in the Polar Sea; the third, commanded by Richard Chancellor, reached the White Sea, and landed at the mouth of the Dwina, close to a convent, on a spot where now stands the town of Archangel. Chancellor gave up the idea of penetrating to India, obtained leave to visit Moscow, and was well received by Ivan II., who entered into a commercial treaty with England.

The Czar also sought to extend the limits of his empire, which he accomplished towards the East by means of the Strelitz, the first standing army of Russia, founded by him. In 1552 he conquered Kasan, and two years after he also made himself master of Astrachan, and Russian boats crossed the Caspian Sea, the greatest inland sea of Asia.

A century previous to these conquests a Tartar chief had gone over to Russia. He was baptized, and received the Christian name of Spiridion. He settled high in the north, where the Vitschegda empties itself into the Dwina, and founded the town of Solvytschegorsk, and began amassing great wealth by a widely extended commerce in furs. The intense trading spirit which still animates the Chinese must have existed in him. There is no doubt that intellectually he was far superior to those who had converted him. Russia was scarcely yet civilized; barbarism and ignorance characterized the people, compared with whom the despised followers of the Koran often appeared civilized.

Thus the Mongolian understood arithmetic; not so the Russian. Spiridion, by introducing the abacus, which the lower classes of Russia, with those of China, use to the present day, conferred a positive benefit on the people. The Russians looked on the simple apparatus—too well known to need description—as a thing of magic; but with the teachableness of the Slavonic race, they soon appropriated the art of the Tartar to themselves, and transferred it from child to child. Spiridion, having trained some able assistants, founded several trading stations along the Dwina and Vitschegda, penetrated along the latter river in an eastern direction as far as the locality of the modern Ust Syssolsk, established salt-boiling houses, which yielded him large profits; and advancing further and further East, he reached the sources of the Kama—yea, the Ural, which he crossed, finally descending into the valley of the Tura, which, already on Siberian soil, pours its icy waters into the Istysch.

Spiridion became the pioneer of the Russian fur trade. As Astor crossed the Rocky Mountains and brought costly furs from the Fraser River, so the Christianized Tartar crossed the Ural to become, through dangers and difficulties, the forerunner of that fur-trade which ruled all the markets of the world, until the Hudson's Bay Company appeared as its rival. But the enemy was watching on the other side of the mountains; his former co-religionists arose against the ever more successful fur-trader. On one of his journeys he fell into their hands, and lost both goods and life. Tradition, ever busy, and ever attaching itself to the outward, took hold of this fact, and reports that Spiridion was planed to death alive, with a kind of plane specially made for the purpose by his enemies; and that from this barbaric art his successors obtained the name of Strogonoff, said to be derived from the Russian word for planes.

But the active spirit of the founder of the house did not die with him; his heirs continued what he had begun, and attained distinctions and such dignities as few other Russian families. Anika Strogonoff, Spiridion's son, protected by Ivan I., caused a great number of Russian families to settle on the Kama and its tributary, the Ischussovaja; he worked salt-mines, extended the fur-trade, and finally obtained from Ivan those wide domains as hereditary fiefs. His three sons crowned the deeds of their ancestry by the conquest of the greatest country. Here we have another instance of the power of commerce as pioneer and spreader of civilization.

The names of these three sons were Iakoff, Grigory, and Semen Anikitsch Strogonoff. Czar Ivan II., who appreciated their worth and the protection they afforded towards the East, granted them new privileges, by virtue of which they built fortified villages, so-called Ostrogs, and small towns in the neighbourhood of the West-Uralian rivers. For their defence they needed soldiers; and, as the wealth and liberality of the Strogonoffs were known throughout Russia, numerous adventurers, honest men and rogues, came to take service with the great fur-dealers. Russian armourers received extensive orders for every kind of material of war, and the once desert regions on the western slopes of the Ural soon resounded with busy life, colonists and artizans being freely invited to settle there. The Strogonoffs followed the example set by Ivan II. in entrusting the chief management of their affairs to Germans.

Then probably it was that the first fair Germans saw the wild Ural, and the strange people living at its foot. The clerks of the Strogonoffs, their sergeants that drilled their soldiers, the correspondents who kept the accounts in their factories, the officials and paymasters, were nearly all Germans. And well they performed their work. The order they introduced, the activity they displayed in every direction, contributed not a little to the successes of the Strogonoffs. Where the Tschussowaja

discharges itself into the Kama there arose in 1558 the small town of Kankor; farther towards its source the strong place Kergedan; and between both extended a long line of fortified log-houses, magazines, and small arsenals. The small army was not idle, for the neighbouring tribes became more and more impatient of the Russian yoke. In 1572 an insurrection of three powerful tribes broke out, and was only put down after severe fighting. The North-east of Russia was thus in safe hands, and Ivan showered fresh marks of his favour on the merchants, who knew so well how to combine the interests of commerce with the policy of the State. But battles with the tribes were only the prelude to what the Strogonoffs were to accomplish on the other side of the Ural.

In Southern Siberia, in the neighbourhood of the modern Urga, lay the famous Mongolian capital Karakorum. There at the end of the 12th and the beginning of the 13th century ruled Dschingis Khan, the terror of the Old World. Driven by this demon the Mongolian people arose like a whirlwind, and became a destroying power. The civilization of Asia and Eastern Europe fell a victim to those wild hordes, which westward spread as far as the Oder, eastward to the Japanese seas, and poured its legions over the lands stretching from the Persian Gulf to the polar ice. But after the death of the mighty warrior his empire fell to pieces, which, however, continued to exist as separate States under Mongolian princes. Such a portion was the Khanata of Turan, which had been established about the middle of the 13th century in the steppes of the Khirgises. The founder's residence was on the Tura, but in course of time the Khans left the spot and took up their abode on the eastern bank of the Irtysch, where they founded the town of Iskir, which afterwards was called Sibir, and eventually gave its name to the whole country. This Mongolian kingdom existed up to the time of which we are writing. The last Khan of Turan was Kutschum; he first introduced Islamism into Siberia, and endeavoured by all means to extend it; but encountered the Strogonoffs. By their mediation, Indiger, Khan of Turan, had already in 1555 acknowledged the supremacy of Ivan, and bound himself to send an annual tribute of 1,000 sable furs, which gave the Czar occasion to assume the title of "Ruler of Siberia" before he ever possessed one square yard of land in that region. But this connection did not last long, as in a few years Indiger was conquered by Kutschum. By this defeat of Indiger Russia seemed to lose her hold upon Siberia, and the question was reopened whether Northern Asia was to belong to the Cross or the Crescent. Then an outlaw, Iermak, threw his sword into the scale in favour of the former, and Siberia became Christian.

Kutschum detected the mighty traders who on his western frontier always kept ready a small but well appointed army; and as he justly considered his power threatened by them, he aimed at destroying their settlements on the Kama and Tschussoraja. To frustrate his plans the Strogonoffs petitioned the Czar to be allowed to erect fortresses in Siberia. Not only was this granted, but the Czar made them a donation of all Siberia, should they conquer it. The Czar, who was quite alive to economical considerations, moreover charged them to establish mines and seek for iron, lead, tin, sulphur, and silver in the enemy's country. But the two elder brothers, Iakoff and Grigory, did not live to see the glorious period of their houses; they died before the conquest of Siberia, leaving two sons, Maxim Iakowleff and Rikita Grigoriewitsch, who, in company with their uncle, Semen Anikitsch, accomplished the great work. The latter, distinguished for his improvements in mining and saline works, was henceforth the soul of the family. Everything prospered in his careful hand, and he was scarcely less experienced in the conduct of war than in the works of peace. He more than once personally conducted his little army against the Mongolians into the gorges of the Ural, everywhere giving proofs of his strategic genius. Germans, Poles, Lithuanians, took service under him; but above all the Cossacks, dispersed by Ivan II., who had hitherto been the scourge of Southern Russia.

We have already mentioned that Ivan had conquered Astrachan, and called into existence Russia's trade with Persia, Bockharia, and the East Indies. Long trains of heavily-laden camels wandered along the roads once trodden by Marco Polo to the Caspian Sea, whence the products of the distant East were carried further into the interior of Russia. But on the Don and the Lower Volga a fierce enemy waited for them, seeking to destroy the beneficial commerce. For there was the home of the Don Cossacks, who, mounted upon their small but hardy horses, were ever ready for fight and plunder, invading neighbouring countries, and returning with rich spoil. The newly-awakened commerce between Russia and the southern East was quite to their taste, and they hesitated not to attack the caravans. But their success was only of short duration. Ivan sent his well-organized Strelitzes; and, dispersed like chaff before the wind, they had to seek refuge in the surrounding countries.

The greatest resistance, however, was offered by Iermak Timofejeff, commanding six thousand bold Cossacks. He knew that his life was forfeited should he fall into the hands of the Czar, and this knowledge drove him to an act of desperation. Whither was he to turn? In the west he was beset by the Strelitzes; to the south lay the Black Sea and the icy wall of the Caucasus, with its warlike mountaineers; to the east the broad Caspian Sea and almost unknown regions; in the north only he seemed to discern a glimmer of hope. There, like independent rulers, stood the Strogonoffs, who just then were complementing their army, and wanted daring hands. Thither Iermak directed his course. Along the Volga, towards the north, his brave Cossacks wended their way, and met with a hospitable reception from the princely merchants.

But Iermak had not come to indulge in idle leisure; his longing for adventures drove him onwards. And the opportunity for great and bloody work soon presented itself, for Kutschum had just then made fresh inroads on the territory of the Strogonoffs, and also rendered himself odious to his subjects by the fanatical zeal with which he forced the Koran upon them. Upon this Iermak based his plans. Behind was Ivan, who would hang him if he was caught; in front was Kutschum, ruling a discontented people, but in whose territory thousands of valuable sable furs were to be won. Iermak could not retreat; hence his watchword was "Forward!" The Strogonoffs, with whose policy the scheme entirely tallied, had every reason to promote it. If it succeeded they were rid of their worst enemy, Kutschum, and could rely on the ever-increasing fur trade always passing through their hands. But if the enterprise should fail they would lose nothing, and be freed from their guest Iermak, who might bring them into discredit with the Czar. Thus they shrewdly calculated the commercial and political chances, and the well-considered plan proved successful.

For when in the summer of 1578 the streams were clear of ice, and the tempestuous floods of the Tschussoraja began to calm down, the bold Cossack thought the moment for action was come. Along the banks of the river he penetrated into the mountains, through which there were not, as to-day, well-kept roads upon which the light *tarantasse* flies along. No guide was to be found in the thinly-peopled mountain region, and Iermak lost his way. As, two and a-half centuries after him, hunger and cold compelled the great Corsican to retreat from Russia, so these same enemies drove Iermak, after having lost a great many of his followers, back to the territories of the Strogonoffs. But, far from being discouraged by the dangers passed through, Iermak became all the more determined to carry out his purpose; for now he had gathered experience, and was convinced that, with better preparations, success was certain.

In the first instance, it was necessary to interest the Strogonoffs more thoroughly in the enterprise, and the merchants, urged by the spirit of gain, supplied him with provisions and munitions of war in rich abundance; and strengthened by a portion of the troops of the Strogonoffs, Iermak set out on his second expedition.

Amidst great perils, fighting the natives and hunger and cold, Iermak, at the end of 1580, reached the Jura. But extraordinary fatigues had almost destroyed his army, so that he could lead only 1,500 men into winter quarters. A second Siberian winter had to be passed through, and what that means, in a northern latitude of 58°, may be inferred from the fact that there, for more than a month, mercury belongs to the fixed bodies. When spring came the army, originally 5,000 strong, consisted of 700 men only, under the command of Iermak and the two younger Strogonoffs. But they did not lose courage, and what they had not accomplished with the greater army they performed with its small, but well-armed and easily-moving remnant, whose progress resembled a triumphal march. Kutschum had come out to meet them. At the confluence of the Irtysch and Tobol his camp stretched for miles, thousands and thousands of his tents covered the ground, and the warriors occupying them seemed to mock all hostile exertions. But fortune favours the bold. The 26th October, 1581, decided Siberia's fate, and rendered Christianity triumphant over Islamism. Firmly resolved to conquer or die, the Cossacks rushed upon the fortified camp, and a terrible fight ensued, whose results seemed doubtful for hours. But strict discipline and fire-arms gave the handful of brave men the advantage over a large host loosely arranged, and armed with bows and arrows only; and though Kutschum repeatedly led fresh troops into the thick of the battle, the victory remained with the Cossacks, and Iermak, without losing a moment, rushed on upon Siber, the capital of the defeated Kutschum. The place was deserted, and immediately occupied by the Cossacks, who gradually extended their sway over the surrounding country and its inhabitants, who came to pay homage to the new sun, and bring their furs as tribute.

Iermak, who saw that he could not possibly with his small

band maintain his position, now sought to regain the favour of the Czar, in which effort he was strenuously supported by the Strogonoffs. Great, therefore, was the astonishment of Ivan when an envoy from the outlaw laid at his feet 2,400 sable furs from the province recently conquered for him, the Czar. Ivan forgave his enemy, and made him governor of the newly-acquired territory, considering that he who had won it was also the best man to keep it. The auxiliary troops Iermak had asked for were also granted, and at once despatched. To Iermak himself Ivan sent an armour of honour, which he had worn himself, as the greatest distinction he could grant him. This Imperial favour, however, proved fatal to the Cossack chief; the weight of the armour drew him down when, in order to save his life from a sudden attack of the enemy, he attempted to swim across the greatly swollen Irtysch. Iermak, who had escaped the gallows and the wrath of his Sovereign, was to perish by his marks of favour. At Tobolsk, which was founded in 1587, on the spot where, at the confluence of the Tobol and Irtysch, Iermak defeated Kutschum, a grateful country erected a memorial to the former robber, on which his name and the date, 26th October, 1581, are graven.

Though the Russians after Iermak's death had yet many a severe struggle to pass through before their power was permanently established, yet they gradually advanced farther and farther into Siberia. Feodor I. planted his standard on the shores of Lake Baikal, and on the banks of the Yenissei, in 1639 the Turgusians and other tribes were made tributaries, in 1698 Kamtschatka was transferred to Russia, and in 1713 the country of the Kuriles. And Russia is still progressing; in 1860 the lands bordering on the Amoor were ceded by China to Siberia, though virtually they had for the previous decade already belonged to Russia.

Whilst Iermak was performing his work, the thirst for gold on the other half of the globe urged the Spaniards from country to country, from discovery to discovery. But in Siberia the small sable drew the Cossacks more and more towards the East, and finally led them to Behring's Straits. The golden period of the Siberian fur trade was not yet passed. They relate that the Promyscheniks—representing the American *voyageur*—who followed in the rear of the actual fur-traders, used to exchange iron and copper pans with the Yakoots for as many sable furs as the vessel would hold.

It was only natural that all these circumstances were favourable to the Strogonoffs, who stood in the middle between Russia and Siberia. And they deserved their successes; they had sent Iermak to Siberia, had supported him, and fought by his side in the battle on the Tobol. The Czar placed all the commerce of Siberia into their hands, and it brought them Royal wealth. They exchanged the products of Western industry for the raw material of Siberia. Village after village, factory after factory, ostrog after ostrog, arose; and in Russia the Strogonoffs, the Czar scarcely excepted, had no equals in riches. When afterwards great gold-washing stations—of which we shall speak anon—were added to their enterprises, the wealth of the Strogonoffs became incalculable; and they made no narrow-minded use of it. When the country called for help, when Poles or Mongolians assailed it, the Strogonoffs were ready with counsel and deed, with money and troops. All Russia knew their merits and patriotic spirit. In acknowledgment thereof the Romanoffs, on ascending the throne in 1613, as well as the Chamber of Commons and the Court of Bojars, determined to leave their right of possessing their own fortresses and troops unimpaired. Moreover, free jurisdiction over their subjects was granted to them, and the privilege of being personally judged by the Czar and the two Chambers only. These extraordinary favours did not render the Strogonoffs overbearing. They lived like simple citizens, remained industrious merchants, and did not become mere drones in the economy of the State, like many of the Russian nobles of the time, who, however, did not hesitate to enter into matrimonial connections with the rich trading family. And so it came to pass that already at the end of the 17th century the most eminent families of Russia were related to the Strogonoffs. At that time there was only one male representative of the house living, Grigory Strogonoff, who resided mostly at Moscow, and made a truly princely use of his enormous wealth. When his wife bore him three sons, Alexander, Nicholas, and Sergius, the family was revived, and from them are descended the many Strogonoffs now living.

But they, too, were to experience that Royal humour is unstable. Peter the Great, who opened the door to western civilization, and wished to centralize his power, could not bear that a state should exist in his State, possessing its own fortresses, troops, and jurisdiction. With a dash of the pen he, by the ukase of 6th May, 1722, deprived the Strogonoffs of all their privileges. In the course of time a period would certainly have come when these privileges would have become extinct of themselves; but the measure was harsh and mortifying against those whose ancestors had won such a position by their activity, intelligence, and blood. The indemnification granted by Peter was paltry; he gave the Strogonoffs the title of barons. Only in the following generation the house—then 300 years old—obtained in a double manner the title of counts. Alexander Strogonoff, the son of Sergius, had married a relation of the Empress Elizabeth, and in 1761 the German emperor, Francis I., bestowed on him the dignity of Count of the Holy Roman Empire, whereupon, in 1798, the Emperor Paul raised him also to a Russian countship.

The Russian Czars have found in the two still existing lines of the Strogonoffs distinguished servants; many have won honoured names as ambassadors, generals, and other state officers. Vigour, activity, and caution distinguish Count Sergius Strogonoff, the present head of the family. Untiringly he developes the Uralian possessions descended to him from his ancestors—salt and iron works and gold washings. He is certainly one of the most zealous champions of the old Russian party, and as such promotes the national welfare to the utmost. He maintains at his own expense a large drawing school at Moscow, founded by himself. He has also acquired a distinguished name by some archæological works.

Since the entrance of the Russians into Siberia, the culture and development of the resources of that country have made the greatest progress. A German writer has justly remarked that the local distribution of the noble metals, like a natural law, determined the colonization of Spanish America and the course of discovery. If for "noble metals" we put "furs," and for "Spanish America," "Siberia," this dictum applies, with some restrictions, to the region we have been speaking of.

3.—The Russian Fur Trade.

The taxes—Iasak—which the Siberian tribes after the conquest of the country had to pay to the Czar, did not consist in money, for they had none, but in furs; and as the capture of fur-bearing animals was the only means by which those tribes could acquire some property, it naturally engaged all their energy and inventive power. Wherefore in no country are there as yet as many traps and modes of trapping animals as in Siberia, where almost every tribe possesses its own kind of snares and self-acting traps. An industrious Yukagire generally after the first fall of snow sets as many as 500 different traps, which he visits five or six times during the winter, to remove his captures, which but too frequently become the prey of the voracious glutton. The Manguas on the Lower Amoor, a Turgusian tribe, employ for capturing the sable a cross-bow, fixed in an upright post, and to whose drawn string a horse-hair is attached, with its end projecting just in front of the arrow, and having the bait tied to it; the sable on pulling at it discharges the bow, and is pierced by the arrow. In modern times the natives make greater use of guns, especially matchlocks, with which very imperfect arm they yet aim and hit remarkably well; for among the thousands of squirrel or weasel-skins that come into the market, there is scarcely one that is not shot through the head. From the smaller villages and dense forests Russian traders bring the furs obtained in return for brandy, powder, &c., to the great trading stations, Yakoolsk, Nertschinsk, Tobolsk, and so on, whence they are sent westward to Europe, or eastward to China.

The sable nominally, but not actually, is still the most important fur-bearing animal of Siberia. From the time when the Strogonoffs brought the Russian ruler the first furs to the present day it has been the reputation of the country, and when Pojakoff in 1614, for the first time passed the winter in the neighbourhood of the mouth of the Amoor, he knew of nothing more costly to bring back with him than sable furs. Even now in Eastern Siberia sable forms the unit for calculating the value of all kinds of fur, is the most acceptable coin in the barter of those nations, and a factor of their wealth. The Chinese also on the Amoor and its affluents levied their tribute from the Turgusians in sable furs, and only unwillingly ceded the "rich sable-land" to the Russians.

Sable has no uniform colour, but offers a series of shades, from almost black to light brown, reddish and yellowish. In calculating the commercial value of the article these differences are of great importance, the darkest furs being the most valuable. An experienced judge of sable can at the first glance tell from what part of Siberia, yea the river whence it comes. The best are found on the Olekma and Aldan; then come those from the Amoor and Nertschinsk; the island Sachalin supplies the commonest sort. The animals have retreated more and more before the advancing trappers towards the East, and are becoming rarer and rarer; but the annual take in Siberia still amounts to about 45,000 head. In Russia, furs of middling quality are worth from eight to ten roubles; for some of the best, especially black with certain white hairs, the silver-sables, as much as sixty

roubles are paid; and the animal being small, and the belly part not being so valuable, a complete cloak requires some eighty furs. So that such a cloak costs about 5,000 roubles.

The ermine, once the most esteemed fur-bearing animal, is now a fallen greatness, since tyrannical fashion has banished it from the ladies' toilette. The small white skin, with its black-tipped tail, is now worth at Yakootsk only from five to eight *copecs* (100 copecs = 1 rouble = 3*s.* 1½*d.*), and the whole yield of Siberia is valued at 200,000 roubles. Nor is the export of weasel and polecat furs of such importance as formerly. But the genus fox in its varieties contributes greatly to the Siberian fur trade. The black fox supplies the most valuable fur, surpassing even the sable; for the average price of a skin is from sixty to seventy roubles, whilst some very choice skins fetch as much as 300 roubles and more. Iermak sent twenty skins as great rarities to the Czar Ivan II., whilst now at least 200 are annually brought to Yakootsk. Only very wealthy Russians can indulge in the luxury of a fur coat of black fox, whilst the skins of the red and other foxes may be had at prices ranging from six to twenty roubles.

The marmot, bear, glutton, ice-bear, lynx, and wolf, all yield more or less valuable contributions to the total of the Russian fur harvest. But they are all surpassed by the value of squirrel (*petit gris*) skins, for the sums obtained for them in the open market are nearly seven times those given for sable fur. The trade in squirrel skins is from year to year assuming larger dimensions. Four millions of them go every year to China, and about three millions to Europe, irrespective of those that remain in the country. There squirrel skin is the most common fur; and von Bär is scarcely at fault when estimating the annual yield of such skins at fifteen millions. The Siberian hare also —different from the European—forms a more important item in the fur trade than is generally supposed. In 1793 the value of the skins and furs exported from all Russian ports amounted to 396,377 silver roubles, of which 266,215 roubles were paid for hare skins, whose annual value now amounts to half a million of roubles.

As the sable lured the Russians to Siberia, the sea-otter drew them across Behring's Straits to North-western America. A hundred and more roubles are given for the skin of this fast disappearing dweller on the coast, which surpasses the brown fish-otter in size, and whose black-velvety, long, and very thick fur is considered the prince of furs, more excellent even than that of the black fox. Until the autumn 1866, the "Russian-American Fur Company," founded under the Emperor Pau in 1799, possessed the fur monopoly in those regions. But in 1866 Russia sold all its American possessions to the United States for the sum of seven and a-half millions of dollars, and the fur company ceded its privileges to a company of San Francisco merchants, who, with the energy of Yankees, are seeking to infuse new life into the declining fur trade of the newly acquired territory.

Taking a survey of the whole Russian fur trade, we find, according to von Bär's estimate (for 1865), that the Russian-American Company sent furs to the market to the amount of half-a-million of silver roubles; European-Russia, to the amount of a million and a-half; and Siberia to the amount of three millions of silver roubles. These figures refer to the markets of the interior, and, in accordance with the requirements of the climate, the greater portion of the furs remained in the country. The value of the quantity exported (chiefly to Germany) amounted to 1,293,366 silver roubles.

Though these are considerable sums, they form but an insignificant item in the commerce of Russia, especially its agricultural branches. In the above-named year (1865) Russia exported cereals, flour, and pulse, to the amount of 60,942,035 roubles; hemp, flax, and tow, to the amount of 38,923,020 roubles; oil-seed, etc., for 17,600,000 roubles; tobacco, for 189,466 roubles, and agricultural products, for 35,532,434 roubles; or in the total to the amount of 153,187,296 roubles. How small in comparison is the export of furs! But these figures show that Russia is eminently an agricultural country, for the above sum comprises three-fourths of all Russian exports, which in 1865 amounted to 203,352,282 roubles, with imports to the amount of 141,660,500 roubles.

4.—Russian Tea Trade.

The tea trade of Russia is closely connected with its fur trade; in fact, both mutually influence each other; and the tea trade also was called into existence mediately through the activity of the Strogonoffs, to whom the Russian mujik is indebted for his beloved tea. Sturdy peasants, drivers, or workmen may be seen wrapped up in their sheepskins, which they keep on even in the hottest room, drinking nearly as many cups of tea at one sitting as Dr. Johnson used to swallow. The temperature of the outer air forms so strong a contrast to these quantities of hot tea, the furnace-like air of the room, and the sheepskins, that the mujik when he throws himself into his sledge, and there sinks into sleep, gives forth the heat stored up in him, as a locomotive its superfluous steam. This state is described as *Pey do tretiaro pota*, "to drink to the third degree." And in reality the drinker, closely wrapped up in his sheepskin, in spite of perspiration, retains sufficient heat in him to the next station, where of course drinking recommences. "Drink-money" there means money to drink, not beer or gin, but tea. Hence Russian towns possess a great number of tea-houses, all day long filled with thirsty souls; so that in some of them as much as from 80 to 100 pounds of the aromatic herb are consumed. And yet the total consumption is not so large as one might expect, for it amounts only to 28 million pounds of tea annually among 60,000,000 Russians, or less than half-a-pound a head, whilst in England it amounts to about 3½ pounds per head. The solution of the question lies, not in the supposed poverty of the Russians, but in the protective duty on tea, by which Russia, in endeavouring to benefit the legitimate tea trade, has nearly ruined it. In fact, not only the Russian tea trade, but Russian trade in general may be divided into two great categories—legitimate trade and smuggling. Monopolies, protective duties, prohibitive tariffs, have assumed such unnatural and enormous dimensions, that under their influence smuggling has attained an extent and importance which are only feebly indicated by the fact that there are actual "smuggling insurance" companies which undertake smuggling into Russia even the most cumbrous and ponderous articles, such as pianofortes, for instance. Protective duties, in fact, only protect smuggling; legitimate trade suffers, and is finally undermined by them. But the Russian Government and people seem to be opening their eyes to the evils of protection and the benefits of free trade.

As Iermak's conquests laid the foundation of the fur trade, they also gave the first impetus to the tea trade with China; but it was only under Peter the Great that this branch of commerce began to assume a regular form by the foundation of trading companies. In those days the exports of Russia consisted chiefly in furs, which the Chinese paid for in noble metals, precious stones, silk and porcelain, cotton and other stuffs, but principally in tea. But the demand for tea increased so rapidly, that soon there were not furs enough to pay for it; the Chinese, moreover, being like other more civilized nations, the slaves of fashion, suddenly discarded wearing furs, so that the importation of grey squirrel skins, which at the beginning of this century had risen to ten millions, fell considerably, and finally dwindled down to one and a-half million. Cotton and woollen goods as well as tanned hide, form about three-fourths of Russian exports to China, whilst tea forms nineteen-twentieths of the imports. Here we may mention one of the peculiar evils of the protective system. The Russian Government had determined to pay for tea only with furs, and to keep their silver. But as the Chinese would not have any more furs, and the Russian traders were unwilling to close their shops, they hit on the following shrewd expedient. The embargo on the noble metals only affected them in bars or money; the Russian traders, to evade the prohibition, transformed their gold and silver into cups and dishes, forks and spoons, or trinkets, and thus paid for Chinese tea. When Government discovered the trick, it passed a new law, restricting the payment in manufactured articles to a third of the purchase. This led to a most complicated tariff, in which, for instance, the price of a chest of tea, costing ninety roubles, was represented by half-a-dozen silver spoons worth twenty roubles, a piece of calico worth thirty roubles, and a piece of cloth worth forty roubles. Still the trade revived, and in 1854 rose to 5,810,000 roubles. But now the Russians found out that by this kind of bargain they were the losers, for the Chinese valued the utensils and trinkets according to their intrinsic worth only, and would give nothing for style and labour, which were lost. To lessen this loss the articles were manufactured in the roughest manner, so that it was only by a strong effort of imagination that such and such things could be looked upon as spoons, dishes, &c. Finally, in 1861, free trade was introduced in gold and silver; but the legitimate trade had in the meanwhile been almost ruined by smuggling, for millions of pounds of smuggled tea found their way into the heart of the country without having paid a farthing duty. The English carried the tea in enormous quantities to Hamburg, whence it was smuggled, chiefly by Jews, even as far as Nischni-Novgorod. In 1861 the Government reduced the duty on the finer sorts by one-half; yet the Russians still pay some 10,000,000 roubles annually for the benefit of the Kiachta tea trade. Common tea, which in China costs 4½*d.* the pound, rises when brought by caravans to Kiachta to 9½*d.*, and at Moscow to twenty-one pence.

The natural difficulties of the land transport from China, in consequence of the length and obstacles of the route, are great

enough, so that it is not necessary to increase them by artificial ones. The tea caravan, with its camels, travels in thirty to forty days from Kalgan, on the Great Wall of China, to Kiachta, on the Siberian frontier. The wide-spreading steppe, only broken by low hills or salt plains, and inhabited by nomadic Mongolians, lies before it. Cow-dung, so-called argols, is far and wide the only fuel obtainable—mutton the only article of food. The *tschoinar saltschin*, or cold wind of the steppes, cutting through bone and marrow, often blows upon the caravans almost perishing; and before Urga, the first town, is reached, the swiftly-running river Tolla has to be waded through. Finally, on the distant horizon, the steeples of Kiachta, the first advanced posts of European civilization—though still in Siberia—appear. But the Chinese frontier town, Maimatschin, has yet to be traversed. It is surrounded by a wooden stockade work, and, though it appears insignificant from without, its streets are yet very regular, and, according to Chinese notions, wide and tolerably clean. Three gates lead from the interior to a meadow, which is neutral ground between Russia and China, and on which much business is transacted. Thence we pass through a gate and are in Kiachta, under the wings of the Russian Double Eagle, which meets us at every turn. Black and white frontier posts, whitewashed houses and wide streets, devoid of human beings, do not lead us to suppose that we are in so important a commercial town. The real frontier population resides at Troizkosawsk, one hour north of Kiachta. Both towns together, in 1862, had only 5,400 inhabitants, among whom the officials and merchants represent the educated classes. There is no doubt that the merchants of Kiachta are very rich; though it may not be said of everyone that he is "rich but honest." Alexander Michie, who, in 1863, visited Kiachta, reports:—"When one of these merchants thinks his affairs somewhat shaky, he takes a journey to Nishsu, Novgorod and Moscow, to visit his creditors, and offer them 50 per cent. The offer is not often refused, for the distance is too great successfully or profitably to sue the debtor."

Almost every merchant has shops in the bazaars of Troizkosawsk and Kiachta, and his first business principle is, rather to sell a little with large profits than much with small profits. Competition, so beneficial in Europe, is quite unknown there; the dealers agree as to high prices, which, even allowing for the great cost of carriage, are most exorbitant. The Chinese at Maimatschin also are considered rich and, to judge by their appearances are so. In China a "round belly" is a sure sign of wealth, and "rolling in money" and "rolling in fat" there are synonymous terms. Both commercially and politically Russian and Chinese are well matched. They know each other's character very well; when some bargain has to be struck, it is a matter of course that each begins talking of totally different and indifferent subjects. A deal of time is lost in circumlocution, which, however, is of no consequence to Russ or Chinese; the end is finally attained, and that is enough.

Kiachta was founded in 1728 as an *entrepôt* for the caravan trade with China, and to this alone it owes its importance. Tea always was the chief article; and though the town, in consequence of its position, will continue to rule the trade between China and Eastern Siberia, yet the tea trade has been materially affected by direct importation through the Eastern ports. Efforts are indeed made to keep up competition, but the caravan traffic, mostly based on barter, can no longer compete with naval commerce.

All tea brought to Kiachta is sold in chests only. The so-called quarter chests (*Kwadratnije*) weigh from 63 to 67 lbs.; the half chests (*Polutornije*) from 87 to 93 lbs. But teas of finer quality are packed in small chests, 32 of which form a full chest The purchaser at Kiachta, before concluding the bargain, takes a sample by means of a small shovel, after having bored a hole in the chest. If he is satisfied with the tea, the chest is sown up in damp cowhide, and thus sent to the European market. There the tea is taken out of the original chest, and tied up in bundles of various weights, if destined for the Russian market.

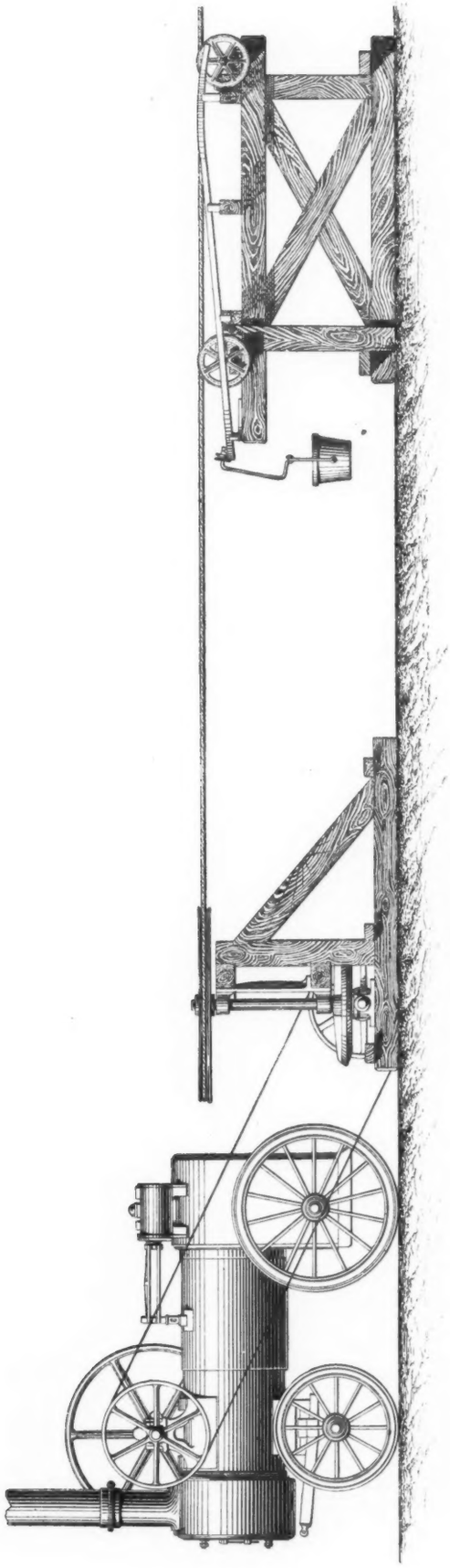
Before Russia had obtained from China the removal of the former restrictions of commerce, the caravan tea of the better sort only reached Europe by way of Kiachta, and in smaller quantities by way of Semipalatinsk. From Kiachta it first went to Irkutsk, and thence mostly to the fair of Nishni-Novgorod. The tea trade assumed its present form only in 1792, and since then the importation of tea has constantly been on the increase. Then it amounted only to 6,851 poods (of 40 lbs. each); in 1820, 101,000 poods went to Russia; in 1847, 226,400 poods; now more than 250,000 poods are imported. This refers to finer sorts only. But the commoner sorts also are of importance. The Siberian nomadic tribes and the Russians beyond Lake Baikal, the Kalmucs and Tartars, use the so-called brick tea, which, throughout Mongolia, is one of the main articles of food. This tea, since 1830, enters duty free; and in 1847 more than 130,000 poods were imported by way of Kiachta. But the halcyon days of Kiachta are past. As late as 1860, 159,316 chests of leaf and 43,658 chests of brick tea were imported. Then Kiachta's part was played out. Compared with China, Russia, as well as the rest of Europe, is still at a disadvantage; for in 1863 the exports thither by way of Kiachta amounted to only 3,333,094 roubles, whilst the imports were more than double, viz., 7,039,408 roubles. The considerable excess had to be made up in cash.

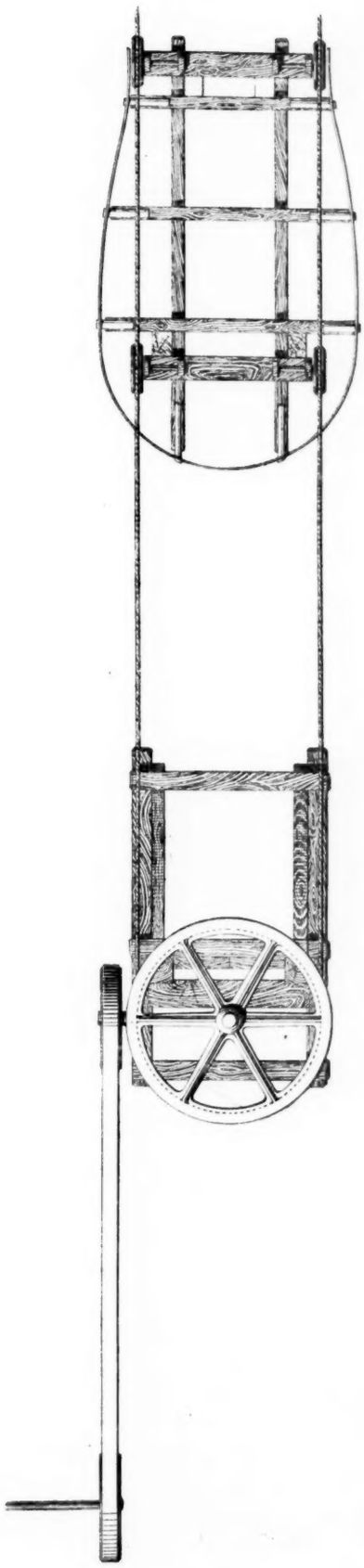
Great Britain is now the largest importer of tea, supplying the whole European continent, Russia excepted; though, as we have seen, even that country, which first opened up the tea trade, now receives some portion of its demand from our shores. And herein we see the cosmopolitan tendencies of commerce, embracing the whole world. Starting with the Strogonoffs on the Ural, we are finally landed from a clipper in the China tea trade in the London Docks!

WIRE TRAMWAYS.

IN the illustration which we give on the facing page we introduce to our readers the main principle of a system of transport originally invented and patented by Mr. Charles Hodgson, C.E., and now being carried out somewhat extensively by the Wire Tramway Company, Gresham Street, London. Differing as does this method of transporting weights from those ordinarily adopted, inasmuch as in some measure the road itself is moveable, it is yet far from being without very special advantages in certain places and under certain conditions. In the first instance it may be pointed out that, comparatively speaking, it neither occupies nor disadvantageously affects in any way the ground, be it cultivated or otherwise, over which its loads are carried, and that with the exception of just the space taken up by the winding-engine and apparatus, and that at the back-end terminus, there is really no land thrown out of its ordinary uses, save the few spots on which are placed the intermediate carrying posts. The principle, as will be readily understood from our engraving, is that of an endless rope passing at either terminus round drums, one of which is driven by steam or any other available power, and supported in the intervening space by means of wooden or other posts bearing transomes fitted with small cast-iron pulleys. The loads are carried by means of a hanger, to which it attached a ∧ shaped piece of wood or gutta-percha, called a box-head, which itself rests on the rope, and by force of friction travels with it. The principal novelty of feature, however, is the hanger, to which the loads are attached, which is in the form of the letter C, having the load hung at the lower end in such a manner that in passing the transomes on the posts, whilst the box-head runs over the pulleys, the load is kept underneath them, the hanger forming the connecting link. At the termini wrought-iron bars are fixed, and so placed, that on the box-head and its load arriving there, two little wheels, attached to the former, engage themselves with these bars, and the supporting point of the load is changed from the rope to these wheels. At these terminal points, or indeed at any others which may be fixed upon, the loads can either be filled into or discharged from the boxes, or the bales, or any other goods of which the traffic may consist, be unhooked; and when this is done, the boxes, grapnels, or hooks, are pushed along the bent shunt-rail until they reach the rope at the other side of the posts, where it is of course running in an exactly opposite direction to that by which they arrived, and they are then carried back to the other end of the line. In the event of it being found necessary to pass the tramway round sharp angles, an arrangement of shunt-rail similar to that used at the termini readily gives the necessary facility for turning. If the loads be placed upon the rope at a distance of, say, thirty yards apart, and the line is running at a speed of about four miles per hour, they will be found to arrive at the termini at the rate of nearly four per minute, a number, however, which can of course be varied to meet the due convenience of loading or discharging, whilst the weights carried can also be regulated according to the nature of the material conveyed and the strength of the line itself.

The main features of the system are these: First, that the original cost is small; that the working cost is also small when compared with the weights carried; that it is admirably adapted to difficult and hilly countries (inclines of one in four can be worked); and that it can be readily set up where any other line of way would be simply impracticable. It seems also well fitted, being so easily movable, for carrying crops of sugar-cane, indigo, or other produce, to the factories, transporting peat from





the bogs to the triturating machines, whilst it is evidently well suited for communication at the Hill stations in India, where the carriage up is now generally done by men or beasts of burden at a very serious cost. Amongst the lines which have been erected and successfully worked are several for beet in the neighbourhood of Amiens, France; some for sugar-cane in the West Indian islands of St. Kitts, Trinidad, Guatemala; one at the Government powder-stores at Purfleet; several at Bilbao, in Spain, for iron ore; whilst Messrs. Worral and Co., of Salford, and Messrs. Watson and Stark, calico printers, Ramsbottom, use them for carrying piece goods; Messrs. Samuel Fox and Co., Limited, Deepcar, near Sheffield, for coal and coke; the Bronfloyd Mining Company, for lead, at Aberystwith; and Messrs. Cuthbertson and Co., for iron ore, at Lydney. There are, besides these, other lines, too numerous to mention, in various parts of England, Spain, South America, Saxony, Italy, &c. &c. We purpose further illustrating this very interesting and effective system of transport in a future issue.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

MANUFACTURE of Sulphuric Acid.—McCULLOCH gives a detailed account of the processes in use in the manufacture of oil of vitriol. He states that in his opinion burners charged with eight to ten cwts. of pyrites at a time are very objectionable; the chief use of them is to save labour, and the other disadvantages they possess quite outweigh this advantage. Light charges, a twelve hours' system, and a properly regulated draught enable the sulphur to be burnt to its best extent. McCulloch states that he has introduced (?) a system of utilizing small pyrites consisting of the introduction of cast-iron plates into the ordinary burner, the heat from the burning pyrites igniting the dust placed on the plates. Dust thus burnt does not contain more than one per cent. more sulphur than the burnt lump ore; 3¼ cwts. of pyrites and ½ cwt. of dust being burnt per twelve hours per burner.

Mason's, Tharsis, Norwegian and Belgian ores are the most suitable, having the following composition:—

	Norwegian. (1)	Norwegian. (2)	Mason's.	Belgian.
Sulphur	46·15	38·17	49·80	45·60
Iron	44·20	32·80	42·88	38·52
Copper	1·20	1·10	2·26	nil
Zinc	2·10	2·32	0·10	6·00
Arsenic	—	trace	0·28	trace
Calcium carbonate	2·55	11·90	0·18	0·11
Calcium sulphate	trace	nil	nil	nil
Magnesium carbonate	—	1·08	—	—
Insoluble	3·20	12·20	2·94	9·00
Moisture	0·40	0·25	0·95	0·36
	99·80	99·82	99·39	99·59
Per centage of sulphur in cinders after burning.	3·5	7·5	3·5	2·5

The great amount of residual sulphur in the second quality of Norwegian ore is due to the large quantity of calcium carbonate present, whereby much sulphate of calcium is formed on burning; the less lime in a sulphur ore the better.

The chief sources of loss of nitrous fumes are (1) the acid in the chamber absorbs nitrous compounds; (2) some nitrous fumes escape condensation in the absorbing towers; (3) sulphuric acid retains nitrous compounds even after passing through the denitrating columns. Of the two methods in use to denitrate sulphuric acid, viz. by the Glover towers and denitration by steam, the author prefers the latter, as he states that whereas only traces of nitrous compounds are retained by the acid in the latter case, large quantities are retained with the Glover towers.

In a set of three or four chambers the two first should be of seven-pound lead, the others of six-pound lead; the side straps should pass *round* the upright supports so as to admit of sinking or stretching, and should not be nailed to the wooden support. Large chambers of 120 to 180 feet long and corresponding height and width are preferable to smaller ones of 60 to 100 feet long, except in small works.

The author considers that in working chambers analyses of the acid produced are unnecessary; all that is required being to form a notion as to whether much or little nitrous fume is condensed in the acid, a point easily established by simply pouring hot water on a known bulk of acid, and noticing the depth of the tint in the red fumes evolved.

Working a set of six chambers together the author obtained 284 per cent. of oil of vitriol on the sulphur charged into the burners, the chambers (measuring 180 × 21 × 20 feet) being worked at 28 cubic feet per pound of sulphur per 24 hours, the temperature of the receiving chamber not attaining more than 90° F. and that of the working chamber not exceeding 160° F. Glover towers were used.

The best draught to use is when there is neither outflow of fumes nor ingress of air on opening the manhole door; this cannot always be attained, as the burners often require "humouring." The strong chamber drip should not exceed 130 or 135 degrees Twaddell, and the steam should not exceed 12 lbs.—from 10 to 12 with an average of 11 lbs. being a good working pressure. *Proceedings of the Tyne Social Chemical Society.*

[*Note by Abstractor.*—The yield stated to be produced by the author (284 parts oil of vitriol per 100 of sulphur charged into the burners), is an impossible result in the case of ore, such as the 2d quality Norwegian described in his paper. 100 parts of sulphur could yield 306·25 parts of oil of vitriol, so that if 284 parts were obtained, the loss would be 22·25 out of 306·25 or 7·3 per cent.; whilst the quantity of sulphur left in the burnt ore amounts to much more than this. If 100 parts of green ore gave only 67 of burnt ore, this would contain $\frac{67}{100} \times 7{\cdot}5$ or 5·0 parts of sulphur out of the original 38·17 parts; *i. e.* 13·1 per cent. of original sulphur would be left in the burnt ore; ore of this quality, however, would give more than two-thirds of its weight of burnt ore, so that the loss of sulphur in the burnt ore is more than 13·1 per cent.

With the numbers given by the author for Mason's ore, the sulphur left in the burnt ore is about $\frac{2}{3} \times 3{\cdot}5$ parts out of 49·80 parts of original sulphur; or about 4·3 per cent. of sulphur is left in the burnt ore. Hence the other losses (leakage, loss of sulphuric acid, &c.) might amount to 7·3 less 4·3, or 3·0 per cent.

C. R. A. WRIGHT.]

In reference to this paper, Glover states that the objections stated by McCulloch to apply to the Glover's towers, do not exist with a properly proportioned and worked tower; so far from the acid containing any nitrous fumes after passing through such a tower, it frequently smells of sulphurous acid. *Chemical News, xxvii.* 152.

LUNGE also states that neither the colleagues of Mr. McCulloch nor other manufacturers on the Tyne, who have thoroughly studied the subject, admit the superiority of the steam denitration process over the Glover's towers; the latter save coals and wear and tear in boiling down the acid, and avoid all loss of acid as the fumes pass again into the chamber, for which very patent advantages they are generally adopted in preference. *Chemical News, xxvii.* 163.

Purification of Oxalic Acid.—HABEDANCK dissolves the commercial acid in the smallest possible quantity of hot absolute alcohol, filters, and recrystallizes from water the acid which separates on cooling.

The mother liquor may be used for the preparation of pure ammonium oxalate by diluting with water, filtering, and nearly neutralizing with ammonia: by boiling the slightly acid liquor, oxamide and oxamethane are destroyed; ammonia is then added to the liquor till alkaline, and the whole evaporated and crystallized. *Zeitschrift f. Analyt. Chemie, xi.* 282.

Preparation of Sulphuretted Hydrogen.—W. SKEY acts on a mixture of zinc and a metallic sulphide, such as galena, with dilute hydrochloric acid. A galvanic action is set up, whereby hydrosulphuric acid is evolved. If bars of the two materials be immersed in acidulated water (the zinc being amalgamated), no action takes place, so long as they are not in contact; but on bringing wires connected with them into contact outside the containing vessel, the action commences. *Paper read before the Wellington Philosophical Society.*

Manufacture of Alkalies.—J. J. KNIGHT proposes to prepare caustic alkalies by treating superphosphate of calcium with common salt and potassium chloride, the mixture being

heated to bright redness for several hours ; hydrochloric acid is eliminated, and a calcium-sodium phosphate (or calcium-potassium phosphate) formed. This is then boiled with a solution of superphosphate if sodium or potassium phosphate is required, or with lime if caustic soda or potash is to be made ; bone earth is re-formed in each case, and is re-converted into superphosphate by means of sulphuric acid.

When superphosphate, dried at 280°, is heated to redness with common salt, air being passed over the mass, chlorine is evolved (from the action of the oxygen of the air on the evolved hydrochloric acid). *Dingler's Polytech. Journal, ccvi.* 332.

Baryta Process for Alkali Manufacture.—G. LUNGE suggests a modification of Wagner's process, based on the mutual re-action of barium bicarbonate and sodium sulphate. Wagner employed a solution of the former salt, adding to it an equivalent of the second ; thereby dilute liquors only were obtained, and the process was inapplicable on the manufacturing scale. Kuhlmann modified the process by employing a higher pressure than that of the atmosphere ; thereby the barium bicarbonate solution is rendered much stronger, and consequently less dilute liquors are obtained.

LUNGE dissolves one part of ordinary sodium sulphate in about 12 of water, suspends freshly precipitated barium carbonate in the solution, and passes a current of carbonic acid through the whole, agitators being provided so as to intermix the liquors thoroughly during the process. The barium carbonate is thus converted into bicarbonate, which re-acts on the sodium sulphate as fast as it is produced, forming barium sulphate and sodium bicarbonate. No extra pressure is actually required, but a pressure of about 15 lbs. in the first of the series of vessels, or *converters* employed, is beneficial. A few hours are sufficient to complete the conversion, and the settling and washing of the resulting barium sulphate is very easy. Bicarbonate of sodium cannot be directly extracted from the solution. On boiling down the liquors carbonic acid is given off and collected for future use, the dry residue left being soda ash of great purity, equal in quality to "calcined crystals ;" the only impurity present is chloride of sodium, derived from the saltcake used. In several experiments on a moderately large scale, 99·5 per cent. of the theoretical yield was actually obtained ; silica, alumina, and oxide of iron, and especially lower sulphur compounds (sulphide, sulphate, thio-sulphate, &c.) cannot possibly be present in soda-ash thus made.

The barium sulphate produced is reduced to sulphide by coal in a furnace something like a black ash furnace ; a revolving furnace would probably answer still better, but even in an ordinary one 80 to 90 per cent. of the sulphate is reduced to sulphide with ease ; the remainder is not lost, being used again after the soluble sulphide has been dissolved out by water.

Waste carbonic acid from the converters, or elsewhere, being blown through the barium sulphide solution thus obtained, sulphuretted hydrogen is given off, and a precipitate of barium carbonate produced, suitable for use in the first stage of this process. The chief difficulty is the utilization of the dilute sulphuretted hydrogen thus developed, it being impossible to use it for vitriol making, at least directly ; but this difficulty is by no means insuperable.

This process presents on the whole the following advantages :

1. Instead of losing 12 to 15, or even more per cent. of the sodium compounds formed, as in Leblanc's process (*vide* Practical Magazine, p. 114), the loss is reduced below 1 per cent.

2. The alkali made is (sodium chloride excepted) almost chemically pure.

The disadvantages appear to be :

1. The process is apparently as costly as Leblanc's, there being no saving in fuel and labour ; a slight (but very slight) loss of barium compounds is experienced, and the carbonic acid (obtained most cheaply from a lime-kiln fed with coke) will cost somewhat.

2. As above stated, it is difficult to utilize the sulphuretted hydrogen.

3. Most of the plant now in use in soda works would be unsuitable to this process, and the plant actually required would probably occupy slightly more space than that now in use ; on the other hand, the repairs would be of a much lighter kind. *Proceedings of the Newcastle-on-Tyne Chemical Society.*

Proposed Improvements in the Soda Process.—D. HILL gives a detailed account of various recent improvements in this manufacture, dividing the processes into six classes.

(1.) Those which obtain either soda or sodium carbonate directly from common salt.

(2.) Those where soda is extracted from other minerals ; *e.g.* cryolite, felspar, sodium nitrate, &c.

(3.) When sodium salts other than the sulphate are used, being usually produced first from common salt.

(4.) Sodium sulphate treated by wet processes.

(5.) Processes where sulphur is recovered from the sulphate, either by balling with a metallic oxide, treating a solution of sulphide with a metallic oxide, or decomposition of sulphides by carbonic acid.

(6.) When sodium sulphate is made in some new way. *Address read before the Tyne Social Chemical Society.*

Methylamine.—VINCENT finds that considerable quantities of this substance are contained in crude pyroxylic spirit, and that by treating the crude alcoholic distillates with dilute sulphuric acid, large quantities of methylammonium sulphate may be prepared. *Bulletin de la Soc. Chim. Paris, xix.* 14 (1873).

LORIN also finds that commercial methylic alcohol contains appreciable quantities of methylamine. *Ibid. p.* 16.

Manufacture of Potassium Sulphate.—SONSTADT states that most of the so-called potassium sulphate met with in commerce is really a double potassium-sodium-sulphate, of composition agreeing with the formula

$$3\,K_2\,SO_4 + Na_2\,SO_4.$$

In order to obtain pure potassium sulphate from this compound, it is dissolved in boiling water, and for every 664 parts of the double salt 149 parts of potassium chloride are added ; pure potassium sulphate separates as a crystalline powder, and the hot liquor strained off from this deposits crystals on cooling : the mother liquors are evaporated and allowed to crystallize ; this process being repeated three or four times until the final mother liquors are saturated with sodium chloride, formed by the double decomposition of the potassium chloride and the sodium sulphate contained in the original double salt. *Chemisches Centralblatt*, 1873, 28.

Manufacture of Sulphocyanide of Potassium.—W. SKEY suspends a porous bag of moist flour of sulphur (which has been boiled with water to free it from gaseous substances with which it is usually impregnated) in a solution of cyanide of potassium ; combination takes place slowly, and at the end of a few days a solution of sulphocyanide is obtained of purity proportionate to that of the cyanide used : if no caustic alkali be present in the cyanide, the sulphocyanide formed is free from sulphide. *Paper read before the Wellington Philosophical Society.*

Production of Salt.—A. PATERA, mining inspector in the saline districts of Austria (proper), describes briefly the modes of evaporating brine, &c., and gives a few hints with regard to the utilization of some of the bye-products. *Polyt. Centralbl.* 1872, 1275.

Preparation of pure Sodium Silicofluoride.—STOLBA mixes a saturated solution of common salt with such a quantity of hydrofluosilicic acid as to produce a copious precipitate. A part of the filtrate from this is then added to a large quantity of hydrofluosilicic acid, so as to throw down a precipitate ; the filtrate from this and the rest of the purified sodium chloride solutions are then mixed, and the precipitated salt washed with cold water till it no longer exhibits a chlorine re-action. The fractional precipitations remove the potassium compounds and silica present as impurities in the materials used. *Zeitschrift für Analyt. Chemic. xi.* 199.

Mineral Phosphates.—ESILMAN criticizes the processes described by Campbell Morfit in his work entitled "Mineral Phosphates and Pure Fertilizers." The process proposed for obtaining pure lime-phosphate is the fractional precipitation of a hydrochloric acid solution of the impure phosphates by means of lime or precipitated ferric or aluminum phosphate, a mother liquor of chloride of calcium and phosphates of alumina and iron dissolved in hydrochloric acid being produced. Esilmann states that these processes yield nothing but phosphates of alumina and iron as a precipitate, *no phosphate of lime at all being thrown down ;* also that some of the modes proposed for economizing calcium chloride are such as to warrant the use of the term "profligate application" in reference to such processes. Moreover the methods proposed by Morfit for separating oxide of iron from phosphate of magnesia, for estimating ammonia in manures, for the determination of nitrates, and for other analytical processes are founded on erroneous principles, and lead to results that can only mislead. *Chemical News, xxvii.* 73.

CAMPBELL MORFIT replies that the phosphate of alumina process was elaborated hastily and without sufficient care and time being allowed for its completion : but that the mixed precipitates of alumina and iron phosphates will throw down

phosphate of lime from its solution in hydrochloric acid, is a point on which he has no doubt. Similarly, lime will precipitate a substance which practically is tolerably pure lime phosphate. As to the comparative economy of various processes for utilizing waste residues, that depends on the locality : a process which may be utterly "profligate" in one place may be economical in other regions. The fact that his analytical processes are imperfect is admitted; but the imperfection, in some cases at least, is due to the incomplete knowledge of chemistry extant as yet, and not to the author's ignorance of the subject. *Chemical News, xxvii.* 104.

ESILMAN rejoins that his own experiments (detailed in full), show very great differences between the true composition of a bone-ash and that arrived at by Morfit's processes of analysis, and that Morfit's own figures show that the phosphate of lime precipitated by his processes is *not* pure nor anything like it; moreover its slimy bulky nature must militate much against its use, either in agriculture or for the manufacture of other compounds by Spence's or Townsend's processes ; whilst the large quantity of phosphate of iron in the so-called *pure* phosphate of lime will greatly diminish its value for any application. On *one* point, however, Esilman thinks that Morfit's conclusions are correct, *viz.* that the superphosphate in use at the present day will ultimately be wholly superseded by precipitated phosphate, there being "no doubt that the latter serves all the manurial purposes of the former, and it only requires time to make the farmer believe it." *Chemical News, xxvii.* 122.

Production of Alum.—SCHLUMBERGER states that when potassium chlorate and aluminium sulphate are brought together alum is formed together with aluminium chlorate; by using strong solutions, 72 per cent. of the alum is obtainable in crystals as a precipitate.

Ferrocyanide of potassium acts similarly on aluminium sulphate, forms alum and aluminium ferrocyanide ; this latter is stable in the dark, but is decomposed by light, yielding a blue precipitate. *Dingler's Polytech. Journal, ccvii.* 63.

Manufacture of Chlorates.—BRANDT prepares chlorates from the solution of aluminium chlorate obtained by the action of potassium chlorate or sulphate of aluminium, whereby alum is formed (*vide* preceding abstract), by addition of a solution of the oxide of this metal, the chlorate of which is required, *viz.* lime, baryta, soda, &c. ; aniline and ammonium chlorates have been thus prepared. *Dingler's Polytech. Journal, ccvii.* 67.

§ 2.—*Metallurgy.*

New Puddling Apparatus.—J. J. BODMER describes a process, the speciality of which consists in the peculiar mechanical arrangements and the treatment of the charge preparatory to its being introduced into the puddling-furnace. This treatment has for its object the thorough mixing of the iron with the oxidizing material, and is effected by running the molten metal between two cylinders, the lower one of which contains the material to be added ; the cylinders revolve slowly, and produce an intimate mixture of the iron and the oxidizing materials. *Polyt. Centralbl.* 1872, 40.

Dormoy's Puddling Process rests on a special mechanical construction, which is not easily explicable without a diagram. We refer therefore to the article itself. *Dingler's Polytech. Journal, civ.* 287.

On the Pressing of Bessemer Steel.—An extract from Mr. BESSEMER'S speech, delivered before the members of the "Steel and Iron Institute," on his election to the presidency, in which attention was called to Sir JOSEPH WHITWORTH'S process for casting steel under great pressure. *Polyt. Centralbl.* 1872. 1,264.

Hardening Graving-tools and Steel generally.—SCHÜSZLEDER states that an extreme hardness may be obtained by making the steel to be hardened white hot, and then plunging it into sealing-wax. After a second it is withdrawn and again inserted, and so on till the steel is quite cold. Steel thus hardened will bore into steel hardened by other processes, and may be used for engraving on such steel, the tool being previously moistened with turpentine. For watch and clock-makers' implements this process is well adapted. *Dingler's Polytech. Journal, ccv.* 419.

Japanese Iron.—BROCKBANK states that the high price of iron has attracted supplies of that metal to England even from Japan. In the south of Europe iron of the highest quality can be made by the old imperfect Bohemian method, at half the price possible in England with all improved appliances and machinery, notwithstanding the disadvantage arising from working on a limited scale. *Paper read before Manchester Literary and Philosophical Society, March 4th,* 1873.

Gilding Iron.—KIRCHMANN rubs the iron with sodium amalgam, whereby the surface becomes amalgamated, even if previously rusty. Strong solution of gold chloride is then applied, and the whole heated till the mercury is volatilized. The gilding thus produced admits of a high polish. Silver or platinum may be applied in the same way. *Dingler's Polytech. Journal, ccvi.* 419.

Gas Furnaces.—FORQUIGNON and LECLERC describe a new form of furnace for heating crucibles of 15 to 20 cubic centimetres, by the aid of which 38·4 grammes of malleable iron can be melted in twelve minutes. *Comptes Rendus,* 76, 116.

Influence of Acids on Iron and Steel.—W. H. JOHNSON finds that by the action of acid solutions on iron and steel the toughness of the metal is reduced, and in the case of steel great brittleness is often produced. An increase in weight takes place due to the absorption of the acid (?) and of hydrogen by the metal, and a corresponding diminution in the breaking strain is produced. Copper is unaffected by acids ; brass becomes rotten, the zinc being attacked.

Iron zinced over with good zinc becomes brittle when heated to redness so quickly that but little zinc is volatilized, the zinc permeating the iron throughout. When heated for some time, so as to expel the zinc, the residual iron is malleable as before. *Paper read before Manchester Literary Philosophical Society.*

Estimation of Manganese in Iron, Steel, Ores, &c.—PICHARD calcines the substance to be examined, and then fuses it with two or three times its weight of sodium carbonate, and dissolves the mass in nitric acid, to which a drop of hydrochloric acid has been added. The liquid is then boiled with a little peroxide of lead, whereby the manganese becomes converted into permanganic acid. The liquor is allowed to settle and decanted into a test-glass, and then carefully compared as to its tint with a solution of permanganate of known strength.

0·1 gramme of substance, 0·2 or 0·3 of sodium carbonate, 5 ccs. of nitric acid, together with 10 ccs. of water and 0·5 grammes of lead peroxide, are convenient quantities. *Comptes Rendus,* 75, 1821.

KESSLER also gives a method of determining manganese, based on the precipitation of manganese dioxide by bromine water, solution of this in a known quantity of antimonious chloride solution, and titration of the excess of antimonious salt by permanganate solution of known strength. *Zeitschrift fur Anal. Chemie, xi.* 249.

LECLERC gives a process for estimation of manganese in soils, almost identical with that described by Pichard. He titrates the permanganate formed by the action of nitric acid and peroxide of lead with a solution of mercurous nitrate. *Comptes Rendus,* 75, 1209.

Covering Iron and Steel with Copper.—GAUDOIN employs three methods for this purpose :—

1st. Dry Process.—The fused metal is coated with a fusible flux of cryolite and phosphoric acid. The metal to be coated is then immersed, having been previously heated to the temperature of the bath.

2nd. Precipitation by Electricity in the dry way.—Chloride or fluoride of copper is fused in a crucible with five or six parts of cryolite, to which a little barium chloride has been added. The object is thus immersed, and the electric deposition proceeded with until a sufficiently thick coating is obtained.

3rd. Wet Process.—Oxalate of copper dissolved in a large excess of quadroxalate or binoxalate of potash, with excess of oxalic acid from a bath, from which copper can be deposited on iron or steel, the coating being adherent. To obtain a thick coat, an electric current must also be employed. *Revue Hebdomadaire,* 1873, 136.

Copper Extraction.—MONNIER roasts sulphuretted copper ores with soda, thus producing sulphates of sodium, iron, and copper ; by increasing the heat, the sulphate of iron is mostly decomposed, the others remaining unaltered ; these are then dissolved out by water, and the majority of the sodium sulphate crystallized out (about four-fifths) ; the mother liquors yield, on evaporation, crystals of copper sulphate mixed with some sodium sulphate ; this then is dried and heated to redness with coal, whereby metallic copper and oxide of copper are produced after the sodium salts are washed out by water. Thus it is unnecessary to use iron to precipitate the copper ; the sodium salts are not lost (about 1 per cent. only is lost), and nearly all the copper contained is extracted (about 98 per cent. of the copper contained is actually obtained). *Dingler's Polytech. Journal, ccvi.* 331.

Hunt and Douglas' Process for Copper Extraction.—This process is employed in Chili and Carolina, and depends on the solution of the copper by the action of chlorides of iron and sodium; cuprous chloride is thus dissolved out; this is precipitated by iron, the resulting iron chloride liquor being used over again. The copper being in the cuprous state, less iron is required for its precipitation than would be requisite were it in the cupric condition; to prevent the passage of the cuprous salt into the cupric, contact of the liquors with air is avoided as much as possible. *Berg und Hütten. Zeitung, xxxi.* 430.

New Silver Amalgam.—PISANI has examined some samples of native silver amalgam crystallized in cubes, and containing silver 95·26, mercury 4·74 per cent.; these crystals were of a dead white tint; others of an iridescent brass-yellow colour contained silver 94·94, mercury 5·06. They occur at Konsberg, Norway. *Comptes Rendus*, 75, 1274.

Separation of Tellurium from Gold and Silver.—A. LÖWE separates tellurium from gold and silver which occur combined with it in the mines of Nagyág in Transylvania, by converting the tellurium into tellurous acid by means of successive treatments with hydrochloric and sulphuric acids, and then precipitating the metals by zinc. Schrötter proposes some slight modifications for the sake of economizing time, but they do not appear to be sufficiently practicable. *Oester. Zeit. f. Berg and Hütt*, 1872, *No.* 28.

§ 3.—*Dyeing, Calico Printing, and allied Subjects.*

Aniline Black.—JAROSSON and MULLER-PACK prepare two solutions. (A) made of

Water	. . .	10 litres
Hydrochloric acid	.	10 kilogs.
Iron	. . .	3 „

Enough water being added after solution to reduce the liquor to 12° B. (B) composed of

Aniline	. . .	3 kilogs.
Hydrochloric acid	5	„

2·1 kilogs. of chlorate of potash are dissolved in boiling water, and the solution added to the aniline liquor. 30 kilogs. of the goods to be dyed are then immersed for two hours in liquor A, and left exposed to the air for twelve hours, after which they are immersed in liquor B and then gently heated in closed vessels to a temperature beginning at 30° and gradually rising to 50°. From three to five hours are required, at the end of which time the black ought to be well developed. *Moniteur de la Teinture, Oct.* 1872.

Bright Scarlet from Fuchsine.—JEGEL heats to 100° an aqueous solution of naphthalene yellow, and adds so much fuchsine as to represent 2 per cent. of the yellow material; silk or wool dyed in this bath acquires a scarlet tint, the shade of which is finer the less fuchsine is added. If the substances be mixed in the cold, flakes of fuchsine are precipitated; these can only be dissolved by protracted boiling. *Moniteur de la Teinture, Jan.* 1873.

Oil Mordant for Aniline Colours.—Two kilos. of oil are agitated with 7½ kilos. of alcohol; 7½ kilos. of water are added, and ½ kilo. sulphuric acid; the whole must be thoroughly mixed to an emulsion before use.

In France, where alcohol is dear, the acid is added directly to the oil, then the water poured in, and the whole well agitated. *Moniteur de la Teinture, Feb. 5th*, 1873.

Violet Rosaniline Derivative.—HOFMANN finds that by the action of benzyl chloride and methyl iodide on a solution of rosaniline in methyl alcohol there is formed a well-crystallized violet derivative, which is the methyliodide of tribenzyl-rosaniline. *Berichte der Deut. Chem. Geselchaft, vi.* 263.

Rouge de Tournay.—This colouring matter, derived from aniline, is obtained as a paste. To produce with it a deep red on cotton, Singer recommends to give the bleached cotton first a strong "Orleans" ground-tint, then to wash it, afterwards to place it in a bath of aluminic acetate solution, in which it remains six hours, and finally to dye it in a warm bath of "Rouge de Tournay." By using more or less of the dye, a deeper or lighter shade may be obtained. *Polyt. Centralb.* 1872, 1298.

Economy of Indigo in Printing Blue: *for Yellow, Green, and Orange.*—Next to the indigo vat is placed a vat containing a decoction of catechu in water. The fabric to be coloured is printed with the yellow or green paste; for green it must have previously received a blue tint. It is next placed in the catechu vat, where it is allowed to remain some time, but not so long that the printed paste begins to be dissolved. The fabric is now placed in the indigo vat, and dyed to the desired extent. The final treatment with potassic chromate solutions brings out the catechu tint, and produces, with the indigo blue, a dark indigo ground.

For Light Blue and White.—Two vats are used, one containing a decoction of 12 pounds of logwood extract with 600 litres of water, the other, a solution of 6 pounds of cupric sulphate in 300 litres of water. The fabric printed with the protecting paste is stretched on the frame, and allowed to sink in the logwood vat; after which it is placed in the copper vat, and then returned to the logwood bath; 6 pounds of alum are now added to the copper bath, and the piece is once more placed therein. Care must always be taken that the protecting paste is not disturbed. The piece is finally stretched, and cleansed in a bath containing a solution of 12 pounds of alum in 300 litres of water. If an indigo tint be required, the printed and stretched piece is first placed in the indigo vat and then in the logwood and copper baths. *Polyt. Centralbl.* 1872, 1102, *from Reimann's Färber-Zeit.* 1872, *No.* 30.

Blue Stamp Colour.—BÖTTGER recommends to dissolve Bleu de Lyons in strong glycerine until the solution is saturated; some Thénand's blue is then added, and the whole thickened to the required extent with gum arabic, previously ground to an extremely fine powder. *Chem. Centralblatt*, 1872, 743.

Blue Dyeing.—GRÄFE purposes to take advantage of the solubility of Prussian blue in solutions of oxalates. The iron salt employed is dissolved in water together with neutral potassium oxalate, and solution of potassium ferrocyanide added; the goods are immersed in this dye liquor, and then dipped into water acidulated with hydrochloric acid and slightly impregnated with tin chloride: the Prussian blue is immediately rendered insoluble so that the fabrics are dyed blue. *Chem. Centralblatt*, 1852, 743.

Dyeing Wood.—The wood should be previously freed from natural colouring matters by treating with a liquor composed of:—

0·500	parts	bleaching-powder.
0·060	„	carbonate of soda.
6·000	„	water.

After half an hour's digestion with this solution, they should be washed with sulphurous acid solution and water, to remove traces of chlorine.

Red. The cleansed wood is treated with a 3 per cent. solution of Marseilles soap, and then dyed with fuchsine; cochineal gives capital shades, the wood being subsequently treated with a solution of tin chloride.

Other aniline colours of all sorts may also be employed; a blue may also be given by indigo after mordanting with acetate of alumina; by also adding a decoction of grains of Persia, green shades may be communicated.

Yellow. Turmeric or quercitron, with acetate of alumina as a mordant.

Black. 250 parts Campeachy wood, 2,000 of water, and 30 of sulphate of copper; the wood is allowed to stand twenty-four hours in this liquor, dried in the air, and finally immersed in nitrate of iron liquor at 4° B. *Moniteur de la Teinture, Dec.* 1872.

Wood-staining.—A fine black tint can be communicated to wood by placing on it a mixture prepared by heating iron-filings for some days with vinegar and vitriol, together with the liquor obtained by boiling Brazil wood, powdered gall-nuts, and alum, with water till the liquor becomes black. Fine woods, especially apple, pear, and walnut, are treated with the product of 4 parts gall-nuts, 1 of logwood dust, ½ of vitriol, 1½ of verdigris boiled with water, the solution being filtered hot; a solution of 1 part iron-filings in wine vinegar is then applied to the wood. Inlaid woods are boiled with the liquor produced by mixing sal-ammoniac with iron-filings, adding vinegar, and leaving for fourteen days in a warm place; after remaining in this liquor for three days, the wood is similarly treated with a decoction of gall-nuts and Brazil-wood. *Chem. Centralblatt*, 1872, 526.

Staining Animal Textures Red.—PUSCHER states that ivory, feathers, gelatine, &c., may be tinted a fine red by immersing for a short time in a solution obtained by mixing ammoniacal solutions of magenta and picric acid; if not ammoniacal the solution is decomposed, and becomes unfit for use. *Chem. Centralblatt*, 1872, 743.

Vermilion Substitute.—BÖTTGER prepares an oxide of copper possessing the bright tint of vermilion by adding 1 part of copper tartrate to a solution of 2 parts caustic potash in 16 of water, 1 part of starch sugar being previously added to the liquid: the whole is then heated to about 60°, until it assumes a bright and deep red colour. The liquor is then poured into a large bulk of rain-water, previously deprived of air by boiling. The precipitated suboxide of copper is anhydrous. *Chem. Centralblatt*, 1872. 755.

§ 4. *Food and Sanitary Matters.*

Cultivation of the Sugar-cane.—COSSA observed that of a large crop of sugar-canes grown at Chivasso, in Piedmont, many plants had the characters of common canes, and yielded no sugar. It was found that two varieties of seeds were formed, and the cause of this was traced to hybridization of the sugar-cane seeds by the ordinary cane pollen. The seeds of the sugar-cane are of a shining black, whilst the others are reddish in shade and germinate more easily: the latter weigh more and contain less water, fatty matter, and nitrogen than the former; the husks, however, contain more silica.

From the readiness with which cut sugar-canes alter, and the ease with which degeneration by hybridization is produced, the author infers that the beetroot is a more advantageous source of sugar than the sugar-cane. *Gazetta Chimica Italiana*, *ii.* 373.

Sugar Refining.—J. SCHROEDER has devised peculiar cooling vats for sugar solutions which have undergone the usual refining operations. The vats, or boxes, containing the hot mass are placed in centrifugal machines, which are kept in rotation until the solidification of the sugar is completed. A yield larger and of a better quality is said to be obtained by this method. The following table shows the result of seven trials carried out before a commission of exports:

No. of Experiment.	Mass filled into boxes.	Raw sugar.	Refined, good.	Syrup.	Yield expressed in per centage.	
					Sugar.	Syrup.
	Pounds.					
1	149	116	—	31	77·92	22·08
2	141	—	96·5	49	68·44	31·56
3	144	110	—	31	76·39	23·61
4	142·5	104	—	36·5	72·98	27·02
5	145·5	—	93·5	55	64·26	35·74
6	142·5	—	91	54	83·86	36·14
7	141·5	—	91	53·5	64·32	35·68

The feature specially claimed as a novelty is that the mass is at once brought into the centrifugal machines without being previously broken up into small pieces. *Dingler's Polyt. Journ. cciii.* 133.

New Saccharimeter.—CORNU and DUBOSCQ have invented a new form of saccharimeter, possessed of the following advantages:—

(1.) The comparisons are more easily made, as the points to be observed are the differences in two shadows or shades, and not of two tints, as in the ordinary instrument.

(2.) The indications can be read off to a much greater degree of nicety.

(3.) Strong liquors can be used, and hence the effects of errors of experiment are diminished. *Revue Hebdomadaire*, 1873, 114.

Yeast Fermentation.—BECHAMP has investigated the behaviour of various forms of fungoid growth on solutions of cane-sugar; alcohol and acetic acid appear to be the normal products; acetic acid was in some cases produced even though no bacteria were formed.

Two samples of yeast, apparently identical, do not necessarily produce the same, or even comparable, results. Contact with air, contrary to the general opinion, not only does not facilitate the formation of acetic acid, but even diminishes it, and also shortens the time required for fermentation. Thus, experiments were made where the carbonic acid formed by fermentation was displaced as fast as produced by a current of air, and when the air was similarly removed by carbonic acid; the more air, the less acetic acid was formed; the better the yeast plant is nourished in the wort, the less the amount of acetic acid formed. Increase of pressure or rise of temperature on the other hand increases the amount of acetic acid; a higher temperature shortens the duration of the fermentation. *Comptes Rendus*, 75, 1036 and 1192.

Detection of Bitters in Beer, from Sources other than Hops.—HOFFSTEDT gives methods for detecting the following sophistications.

Picrotoxin, soluble in ether, spirit, and water.

Absinthin, soluble in ether, and spirit, not in water.

Menyanthin, difficultly soluble in ether and cold water, readily soluble in warm water, and separating again on cooling; becomes brown and finally violet with strong sulphuric-acid.

Quassiin, difficultly soluble in ether; soluble in 222 parts of cold water; not coloured by sulphuric acid.

Colocynthin, insoluble in ether, readily soluble in cold water; becomes red and, later on, brown with sulphuric acid.

Lupulin, the bitter principle of hops, is precipitated by lead acetate; is not precipitated by tannin, and is soluble in ether and spirit, but not in water. Picrotoxin and absinthin are not precipitated by lead-acetate but are by tannin; the other three are precipitated by neither re-agent.

Enders and Kromayer have stated that absinthin is precipitated by tannin; this the author states is not the case.

Lupulin and quassiin do not reduce an ammoniacal solution of silver, whereas the other four bitters do so; absinthin, however, only does so slowly and on heating. *Upsala, Läkarefören Förhandl.* 7. 431.; *N. Jahrbuch. Pharm.* 38. 215.

Action of Potash-Salts in Fermentation—KNAPP finds that the presence of small quantities of potash salts accelerates the fermentation of sugar by means of yeast; but the contrary effect is produced in presence of larger quantities. Soda salts also accelerate the action, but less energetically than potash salts; the retarding action also is manifest sooner than with potash salts. Ammoniacal salts also accelerate fermentation, but to a less degree than potash salts.

Disodium phosphate, $Na_2 H PO_4$, completely stops fermentation, probably by preventing the inversion of the sugar; most salts of alkaline character produce the same result as do also strychnine and quinine; potassium phosphate, however, only stops the fermentation for a while, and not altogether. *Annalen der Chemie & Pharm. clxiii.* 65.

Purification of Alcohol by means of Charcoal.—By passing crude alcohol distillates through filters constructed of charcoal in grains (not powder) arranged in a vertical column, the essential oils and other substances are removed and an alcohol obtained, possessed of a much higher degree of purity of taste and odour than the substance originally used. 100 kilos. of charcoal will disinfect and purify 6,800 litres of alcohol. In Sweden, where the alcohol used is at only 47°—50°, this result is often attained, but elsewhere, when the alcohol employed is stronger and less care is taken during the process, a much less useful effect is produced by the charcoal employed. *Annales Industrielles*, 1872, *p.* 824; 1873, *p.* 27, 55, 85.

Vermouth.—E. DECAISNE states that the liquor sold under the name of "Vermouth," and manufactured from white wines and certain tonic and bitter plants, is a powerful excitant. Like alcohol and absinthe, it produces a condition of body like acute alcoholism, or chronic alcoholism when taken in excess; its chief danger, however, lies in the liability to adulteration. Like quinine wine and other tonics it should be used solely as a medicine, and not as a beverage. *Les Mondes*, 1873, 532.

Ripening of Grapes.—POLLACCI finds, by comparing the amounts of sugar and acid in the external and internal portions of the flesh of the fruit respectively, that the most central portion of the fruit is the last to ripen, as it contains the most acid. During the ripening, the sugar gradually increases and the acid decreases. At a certain stage the increase of sugar ceases, but this takes place before the cessation or diminution of acid; hence the point of ripeness must be considered to be when the acid ceases to diminish, and not, as is usually supposed, when the sugar ceases to increase.

Grapes from Aleatico, Procanico, and Muscatel (white) were experimented with, gathered in August, September, and October. *Gazetta Chemica Italiana*, *ii.* 392.

Olive Cake.—Spanish Olive cake, which had been subjected to two pressings to extract oil, had the following composition:—

Moisture	10·77
Albuminöids	8·56
Fatty matter	25·69
Crude fibre	28·64
Non-nitrogenous extractive matter	22·36
Ash	3·98
	100·00

In Spain the cake is employed as fuel; without doubt, a much larger quantity of oil might be extracted by solvents, *e.g.* fusel-oil, (*vide* article on Wool-scouring, "Practical Magazine," p. 53,) bisulphide of carbon, &c., &c., or the cake might be employed as food for cattle. *Landw. Versuchs-Stationen, xv.* 466.

Artificial Butter.—MEGE-MOURIER makes a substitute for butter by cutting up fresh beef suet into small pieces, and digesting it with an aqueous solution of carbonate of potash, and fresh pieces of sheep's stomach cut into small fragments, the mixture being kept at 45°; a fatty matter rises to the top; this is separated, and subjected to pressure in a hydraulic press; a solid stearine suitable for candle-making is left, and a semifluid oily portion squeezed out; this latter is well churned with milk and water in the proportion of 50 kilogrammes of fat, 25 litres of milk, and 20 litres of water, 100 grammes of milk-infusion of cows' udders, and milk glands being added together with a little annatto. The butter thus made keeps well, especially if melted so as to separate the water, and is recommended by the victualling department of the French Navy. *Revue Hebdomadaire de Chemie Scientifique et Industrielle.*

Silicate of Soda as an Antiseptic.—RABUTEAU and PAPILLON have extended and verified their former observations on this subject; they find that 1 per cent. of the salt added to fresh blood dissolved the globules in about an hour; the whole remained inodorous and free from vitrios for eight days, after which a slight odour of decomposition was observable. Similarly 1 per cent. added to pus, from a patient suffering from purulent pleurisy, stopped the decomposition which had already commenced; the whole remained inodorous for six days; the globules were not dissolved with this quantity of salt, but were with a larger proportion. Oxbile and fresh eggs, when beaten up with 1 per cent. of silicate, were preserved for ten and twenty days respectively. When dilute silicate of soda solution is applied to the skin after rubefaction by a sinapine plaister, the redness disappears and the pain ceases; if the plaister itself be previously dipped in the solution, its rubefacient action is not exerted. *Comptes Rendus*, 75, 1030.

Potato Disease.—J. B. HANNAY has examined potatoes suffering from disease, and others of the same kind not tainted. The chief noticeable differences are, that the diseased roots contain more potassium, chlorine, and sulphates, and less soluble phosphates than the healthy plants. The author concludes that the disease is a kind of constitutional decay, and is more suited to the naturalist or physiologist than to the chemist. *Paper read before the Glasgow Philosophical Society.*

Insecticide of Peyrat.—PEYRAT has patented the use of a composition of lime, carbolic acid, and naphthalene for the protection of vines from *phylloxera*, and for disinfecting purposes generally. For the first purpose it is admirably adapted, the results of experiments on its use being highly satisfactory. *Revue Hebdomadaire, Dec.* 1872.

Coignet Manure.—A manure prepared from bones and animal matter, and containing 7 per cent. of nitrogen and 30 per cent. of phosphate of lime (in a state of division, which renders it easy of assimilation by plants) is prepared by "Coignet père et fils," at a very moderate price, 30 francs per 100 kilogs. *Revue Scientifique*, p. 692, *Jan.* 1873.

Preservation of Albumen for Photographic Purposes.—ZAY beats whites of egg to a froth, which is then set aside to dry spontaneously. A hard, brittle substance is thus produced, which only requires rubbing up with water and straining when wanted for use. *Chem. Centralblatt*, 1872, 743.

Detection of Noxious Substances in the Atmosphere.—SMEE takes a funnel drawn out to a point and filled with ice, and places this, supported by a convenient stand, in the air to be examined. The moisture of the air condenses on the sides of the funnel, and trickles down into a vessel placed to receive it. By microscopical or chemical examination, the amount of ammonia, &c., and the presence of organic germs in the water thus condensed is ascertained. *Paper read before the Chemical Society, Feb. 20th*, 1873.

Injury to Trees and Shrubs by Coal-gas.—From a series of experiments made in Berlin it appears that an escape of ordinary coal-gas from pipes, &c. exerts a highly deleterious action on vegetation. 25 cubic feet of gas per diem distributed through 576 cubic feet of earth (a plot of 144 square feet and 4 feet deep) speedily killed the rootlets of trees of all kinds in contact with the gas-impregnated soil. The more close and compact the surface of the ground, the more speedily was the effect produced. *Dingler's Polytech. Journal, ccvi.* 345.

Arsenic Poisoning by the Use of Pigments.—FLECK states that when arsenite of copper (especially Schweinfurth green) is used as a pigment for carpets, wall papers, washes, &c., not only does the air become impregnated with fine dust containing copper and arsenic, but also arseniuretted hydrogen is sometimes given off from the action of moisture and organic matter on the arsenic compound. Starch and gelatine, such as are used for wall sizes and cementing materials, more especially produce this result. Aniline dyes which contain arsenic also lead to the evolution of arseniuretted hydrogen. The presence of excess of arsenious oxide (almost always present) is greatly conducive to the evolution of arseniuretted hydrogen. *Zeitschrift fur Biologie, viii.* 444.

Potassium Iodate as a Poison.—F. MELSENS finds that whereas iodide of potassium is innocuous, the iodate acts as a poison; it becomes reduced to iodide in the organism, and probably its poisonous action results from the oxidizing action thus exerted on certain constituents of the body. *Annales de Chimie and Physique* [4] *xxv.* 157.

Poison of the Cobra Capella.—The effects of this poison do not appear to be materially diminished by keeping in well-closed vessels, specimens thus preserved producing fatal effects when subcutaneously injected into various animals. In chemical composition it approximates to yeast, containing:

Carbon	46
Nitrogen	13
Oxygen	6
Sulphur	25
Hydrogen	10

whence it appears probable that the poison is of the nature of an animal ferment, and that it acts like other zymotic poisons. *Medical Press and Circular.*

§ 5.—*Fuel, Illumination, Photography, etc.*

Coal Dust as Fuel.—Bituminous coal dust or anthracite powder is mixed into a stiff paste with about 7 per cent. of plastic clay; the whole is made into bricks, which are dipped into a solution of resin in benzene, whereby a glazing or waterproof coating is produced. *Chem. Centralblatt*, 1872, 559.

Chalk as Fuel.—The addition of chalk to coal is said to cause a notable economy in fuel when the mixture is burnt. The fire is first lighted with wood and charcoal, then a layer of chalk is added, and then a layer of fuel, and so on. A fire thus made up is stated to last a long time, to give out a good heat, and to be applicable to the boilers of locomotives. (?) *Les Mondes*, 1873, 493.

Ammonia in Coal Gas.—HONGEAU estimates the quantity of ammonia present in coal gas by reading off the bulk of gas which has to be passed through a known quantity of dilute sulphuric acid reddened with litmus solution, so as to restore the blue colour. *Comptes Rendus*, 76, 52.

Tar Distillation.—R. F. SMITH states that the average composition of coal tar is as follows:—

One ton of tar, sp. gr. 1·145 = 195·7 gallons, yields

Ammonia liquor	3 gallons
First runnings	6 „
Light oil	21½ „
Creosote	66 „
Pitch	11 cwts. 3 qrs.

The "first runnings" on rectification furnish

48	per cent. of rectified benzole at 50 per cent. =	2·88	gallons per ton of tar
20	„ solvent naphtha	1·20	„ „
5½	„ burning naphtha	0·33	„ „
11½	„ "tailings"	0·69	„ „
15	„ loss	0·90	„ „
100		6·00	

The light oil yields

7	per cent. of solvent naphtha =	1·49	gallons per ton of tar
15	„ burning naphtha =	3·18	„ „
75	„ pitch oil =	16·00	„ „

So that in all a ton of tar yields 2·88 gallons of 50 per cent. benzole, 2·69 of solvent naphtha, 3·51 of burning naphtha, 83 of creosote oils, 3 of ammonia liquor, and 11¾ cwts. of pitch.

Difficulties are met with in extracting anthracene from the pitch, principally from the want of suitable flue arrangements, so as to regulate the heat in such a way that the pitch is pro-

perly coked without risking the fusion of the iron retorts used. Clay retorts do not answer. About six hours are required to drive off all the volatile matters, but a much better coke results if the heating be continued longer. At first, hydrogen and water vapour are evolved with a little oil, of specific gravity 0·97, in which occurs a little naphthalene; coking commences when about two-thirds of this have passed over; then permanent gases and hydrocarbons of low boiling point are evolved, and finally a reddish or yellow sublimate of impure anthracene.

100 parts of pitch yield		
Anthracene oils, chrysene, and pyrene, &c.	27 to 30	parts
Gases, steam, and about 0·2 per cent. of light oils	35 to 18	,,
Coke	28 to 52	,,
	100 100	

Paper read before the Glasgow Philosophical Society, Feb. 24th, 1873.

Coal Tar and Pitch.—BEHRENS states, that the higher the temperature of distillation the more solid products are formed; tar from gas retorts contains more benzene, toluene, naphthalene, and solid hydrocarbons than that obtained from Pauwel coke furnaces; the latter contains principally liquid hydrocarbons, also much that is soluble in alkalies, but very little carbolic acid. By "cracking," or distillation so as to break up the more complex hydrocarbons into liquid ones, and coke or pitch, products are obtained varying in nature with the heat employed. If heavy coal oils are dropped into a distilling apparatus at a bright red heat, naphthalene, 2 per cent. of benzene and toluene, a little xylene, and traces only of higher homologues are produced; at lower temperatures the oil is less completely decomposed; at higher ones, naphthalene is formed instead of benzene. The graphtoidal coke left in the furnace is an admirable fuel for high temperatures.

Pitch when passed through a red-hot tube gives about 250 times its bulk of gases, mostly hydrogen; distilled in a retort it gives an oil containing pyrene, chrysene, and anthracene; 48 to 52 per cent. of coke is left. When distilled with superheated steam, anthracene is obtained, and a very brittle pitch, which is used for fuel when mixed with coal-dust and formed into bricks. *Journal für Prakt. Chemie.* [2] *vi.* 277.

Matches free from Phosphorus.—Matches from Sweden were found to be tipped with an igniting composition made up of the following substances:—

	In 100 parts.
Glass	8·77
Glue	7·12
Potassic bichromate	5·59
Potassic chlorate	46·76
Ferric oxide	4·09
Manganese	13·07
Sulphur	7·41

It is supposed that the following proportions were employed in the manufacture of the composition:—

Glass	1¼ pound
Glue	1 ,,
Potassic bichromate	⅘ ,,
Potassic chlorate	6¾ ,,
Ferric oxide	½ ,,
Manganese	2 ,,
Sulphur	1 ,,

In consequence of the small proportion of oxygen-yielding substances to sulphur, a large quantity of sulphurous acid is evolved on igniting the mass.

In another composition, likewise from Sweden, WIEDERHOLD found to 1 of sulphur 21 of potassic chlorate; this composition yielded no free sulphurous acid, the sulphur being wholly oxidized to sulphuric acid. *Dingler's Polyt. Journ. cciii.* 75.

Coloured Lights.—DR. E. JACOBSEN recommends the so-called *Holtz's* compositions for red and green flames; these consist of shellac and strontic and barytic nitrates respectively. The entire absence of potassic chlorate from the mixtures makes it not unsafe to keep them in store. *Polyt. Centralbl.* 1872, 1296.

Dry Process for Photography with Salicin.—COOPER takes 24 grammes of a saturated solution of salicin in water, 12 grammes of a solution of tannin (1 to 8, with a little carbolic acid), 6 grammes alcoholic gallic acid solution (1 to 10), 1 gramme white sugar, and 84 grammes distilled water. The washed plates are dipped in this bath for one minute. *Photographic Arch. xiii.* 229.

Action of various portions of the Spectrum on the Decomposition of Carbonic Acid by Plants.—PFEIFFER enclosed small branches of the *elodea canadiensis* in a vessel filled with aqueous solution of carbonic acid, and then exposed them to light of various colours obtained by forming a large spectrum of solar light, and screening off the portions not required; by counting the bubbles of oxygen given off in a given time, a fairly approximate idea could be formed of the relative powers of various parts of the spectrum. Contrary to the opinions of Lommel and Müller, and in accordance with those of Draper, he found that the curve graphically representing these various actions is pretty nearly coincident with the curve of visible brightness—*i. e.* being at a maximum in the yellow. The following mean values were obtained:—

Red	25·4
Orange	63·0
Yellow	100·0
Green	37·2
Blue	22·1
Indigo	13·5
Violet	7·1

Paper read before the Marburg Society of Natural Science.

Photographic Paper.—Partly from the nature of the materials used for paper-making, partly from imperfect separation of coarse particles of rag pulp, the ordinary photographic papers are liable to have a surface and texture which does not allow of the paper being used for the preparation of negatives. Moreover, the inequalities in the paper often cause particles of metal to be deposited on the surface of those roughnesses derived from the drying rollers, &c.; these metallic particles cause stains, "tears," "ghosts," &c., to be visible, owing to the action of the metal on the chemicals used. In order to obtain a better class of paper the "Société d'Encouragement" offers a prize of 2,000 francs (£80) for the manufacture of photographic paper exempt from the defects possessed by most of the paper at present met with in commerce. *Annales Industrielles*, 1873, 183.

§ 6.—*Electricity and Telegraphy.*

New Thermo Battery.—MURE and CLAMOND have constructed a battery of sixty couples of iron and lead sulphide, the electromotive force of which is equal to two Bunsen's cells; with a consumption of about 158 litres of coal-gas per hour, 3·3 grammes of metallic copper can be precipitated, representing a cost of about 11·8 francs (nearly ten shillings) per kilogramme (in Paris gas costing 30 centimes the cubic metre). To effect this, electrodes are employed with 72 square centimetres surface, and are placed 1 centimetre apart.

A battery of 150 large pairs of this kind has been constructed; it is equivalent to about five medium-sized Bunsen elements; this is conjoined with another battery of 560 smaller couples, representing about 60 Daniell's elements; the consumption in each case is about 800 litres of gas per hour. *Dingler's Polytech. Journal, ccvii.* 125.

Gramme's Magneto-electric Machine.—To produce a continuous current, GRAMME makes a circular electro-magnet with consecutive poles revolve in front of the poles of any kind of magnet, the currents produced being received in a plane perpendicular to the poles. The movable electro-magnet is composed of a soft-iron core, on which is wound a metallic thread, divided into a series of small bobbins connected with a bundle of metallic plates, each bobbin communicating with one of the plates, and being separated from it by only a single thickness of silk. A Daniell's cell is used at first to excite the magnet; subsequently the action is kept up by means of the residual magnetism of the electro-magnets, according to the method of Wheatstone and Siemens.

A machine weighing 460 kilogs. with 165 kilogs. of thread wound on the electro-magnets, each of which weighs about 40 kilogs. requires about 1 horse-power to produce 300 revolutions a minute. A current is thus produced of tension equal to that of two Bunsen cells; its quantity corresponds to 32 elements (of what size?); this current will fuse an iron wire of 0·003 metres diameter and 0·3 metre in length.

Christofle, of Paris, has made some comparative experiments on the use of this machine for the electro-deposition of silver as compared with a Wilde's machine, with the following results:—

GRAMME'S MACHINE.

Surface of Anode.	Speed.	Deposit per hour per square metre of surface.
5·3550 mg.	300 turns 6 baths	0·143 kilogrammes.
"	"	0·141 "
"	"	0·143 "
"	"	0·146 "
3·5700 mg.	300 turns 3 baths	0·198 "
"	"	0·202 "
"	"	0·205 "
2·6775 mg.	2,400 turns	0·225 "
"	"	0·217 "
"	"	0·216 "

WILDE'S MACHINE.

Surface of Anode.	Speed.	Deposit per hour per square metre of surface.
2·6775 mg.	2,400 turns	0·158 kilogrammes.
"	"	0·170 "
"	"	0·179 "
"	"	0·176 "

Practically, the Gramme machine gives no better results with a speed of 2,400 revolutions than with only 300; the Wilde machine, however, requires this high speed, and gives results no better than the Gramme machine at one eighth of the speed. Moreover, it is extremely difficult to keep piles in good order, and the cost of deposition by voltaic electricity is much greater than with induced currents. *Revue Hebdomadaire*, 1873, 136.

Magneto-Electric Sieve.—VAVIN has constructed a machine for separating iron and steel filings, turnings, &c. &c., from those of copper or brass; it consists of two hollow superposed cylinders, the surfaces of which are made up of alternate strips of iron connected with series of magnets and strips of copper: the filings to be separated pass between the cylinders, when the copper, brass, &c., pass on, while the iron and steel are retained. The cylinder can be made to revolve by hand or by steam if required. *Revue Hebdomadaire*, 1873, 110.

Nickelization by Galvanism.—This paper is a claim to priority regarding the usual methods of covering objects with nickel. Professor BOETTGER, the well-known technologist at Frankfort, as long ago as thirty years described methods which have since been rediscovered (?) by various chemists. *Dingler's Polytech. Journal, cciv.* 152. *From Polyt. Notizbl.* 1872, *No.* 7.

§ 7.—*Miscellaneous.*

Preparation of Æsculin.—FAIRTHORNE moistens pulverized horse-chestnut bark with weak ammonia, and makes an ammoniacal extract: this is evaporated to a syrup, and mixed with pure alumina; the paste is then dried, pulverized, and boiled with strong alcohol which dissolves out impure æsculin; the crude product may be purified by washing with water and ether, and with benzene. *Chemical News, xxvi.* 4.

Oleate of Alumina Lacquer.—PUSCHER prepares a lacquer which is suitable for covering metal which is required to be heated, by adding alum to a boiling dilute solution of soap: a transparent alumina soap is precipitated; this is well washed with boiling water, dried, and dissolved in oil of turpentine. Metal coated with this composition does not become covered with blisters when heated. *Pharmaceutische Centralhalle, xiii.* 399.

Filtration under Pressure.—TICHBORN employs parchment paper prepared by floating Swedish filtering paper on an ice-cold mixture of 2 parts pure sulphuric acid and 1 part distilled water, so as to convert one side only of the paper into parchment, and washing thoroughly the resulting product. Instead of this paper, a double filter of parchment paper and of ordinary filtering paper, the latter being inside the former, may be employed. *Zeitschrift für Analyt. Chemi. xi.* 298.

Drying Chamber with Transparent Walls.—OUDEMANS fixes mica plates into the walls of a hot-air closet so as to inspect the substances inside without cooling the whole by opening a door. *Zeitschrift für Anal. Chemi. xi.* 289.

Preservation of Charred Paper.—Collodion is poured over the charred paper. In a few minutes this dries, and a tough transparent coating is produced, through which the printing, &c., can be seen. Bank notes and other documents charred by fire have been thus successfully treated. *Scientific American.*

Explosions in Flourmills.—When flour mixed with bran is heated to 450°, inflammable gases are given off. Possibly this may account for certain explosions that have taken place, the grain having been overheated by friction during the grinding, and a spark from the millstones having fired the explosive mixture of air and gas thus produced.

Dry flour, disseminated through the air, burns like resin-dust (or lycopodium, used at the theatres for artificial lightning). In several instances this has been the cause of accidents, through the incautious bringing of a flame near the air of the room thus impregnated with dust; and in some instances the firing has apparently arisen from sparks struck by the stones.

Spontaneous combustion, even when the substances were kept very warm, has never been observed in flour or grain warehouses, even where large stocks were accumulated together. *Dingler's Polytech. Journal, ccvi.* 417.

Bone Industry.—Bones from the butchers, and from a variety of other sources, are first heated so as to extract grease, then boiled by steam to dissolve out gelatine; after boiling, the whitened residues are dried and ground in a mill. Besides grease and gelatine, there are thus obtained:—

Coarse bone powder, worth 160 francs the ton.				
Bone flour . .	"	200	"	"
Crushed bones. .	"	125	"	"
Superphosphate .	"	250	"	"
Animal guano . .	"	137	"	"

The superphosphate is made simply by treating the bone powder with dilute sulphuric acid; the animal guano consists of the suet and fat residues, and the residues from the edible portions, dried and ground to powder.

This industry, though but little known in Europe, has attained to a considerable magnitude in Australia. *Annales Industrielles*, 1873, 222.

Japanese Paper.—PAVY, FIRETTO, and CO., manufacture the article known as "Japanese paper," and used for making imitation *Cretonnes*, by making a paper pulp and treating it with the following mixture:—Pulp (or, rather, paste), 100 kilogs.; milk of lime, 200 litres; sulphate of soda, 3 kilogs.; American potashes, 2 kilogs.; common soap, 3 kilogs.; linseed oil, 1 kilog.; sulphate of ammonia, 1 kilog. The product is blanched in a bath of bleaching powder at 4°, to 300 litres of which 200 grammes of sulphate of alumina, 500 of carbonate of soda, and 500 of oxalic acid are added. The required colouring matter of animal or vegetable origin is then added, and the whole rendered impermeable by treatment with sulphate of copper solution, or linseed oil and fatty and resinous matters. The whole is made uninflammable by means of a mixture of phosphate of ammonia and alum, or of sulphate of soda, alum, and bichromate of potash. *Revue Hebdomadaire*, 1873, 117.

Essences entitled "Eau de la Couronne" for depriving Fabrics, &c., of Fat.—CKIANDI employs the lighter hydrocarbons contained in petroleum for this purpose; the "Eau de la Couronne" is simply a very highly purified article of the kind made from carefully selected sources, and treated successively with sulphuric acid and caustic soda, so as to eliminate impurities and ingredients of bad odour. *Revue Hebdomadaire*, 1873, 123.

Artificial Ivory.—WELLING takes a mixture of powdered white shellac (10 parts), acetate of lead (4½ parts), ivory dust (8 parts), and camphor (5 parts); these ingredients are finely pulverized, well mixed, and heated and pressed into warm moulds, or rolled into sheets, &c. *American Journal of Pharmacy, March*, 1873.

Tommasi Hydrothermic Engine.—This engine is stated to have been improved in a variety of ways, so that a machine of 25-horse power can be made for less than 10,000 francs (£400). Only one litre of boiler space per horse power is required; consequently there is great economy in space, and therefore in cost. The motive power is derived from the expansion of oil, whereby a pressure of 300 to 500 atmospheres is attained; nevertheless, explosions are impossible, as there is no compressed gas or vapour employed. A full description is promised shortly. *Les Mondes*, 1873, 494.

Use of Glycerine to prevent Boiler Incrustation.—ASSELIN reports to the "Société des Ingénieurs Civils" that glycerine increases the solubility of lime salts, and forms soluble compounds in certain cases; and that consequently it tends to diminish boiler crust; moreover, it causes the lime salts to precipitate as gelatinous non-adherent masses, and not as a compact, hard deposit. One part of glycerine may be added to the boiler for every 3,000 or 4,000 parts of fuel in the case of the worst kind of water, less for better qualities. At the end of from two to four weeks the turbid residual water in the boiler should be blown off. *Annales Industrielles*, 1873, 143.

THE GATLING SYSTEM OF FIRE-ARMS.[1]

THE gun consists of a series of barrels in combination with a grooved carrier and lock cylinder. All these several parts are rigidly secured upon a main shaft. There are as many grooves in the carrier and as many holes in the lock cylinder as there are barrels. Each barrel is furnished with one lock, so that a gun with ten barrels has ten locks. The locks work in the slots formed in the lock cylinder, parallel to the axes of the barrels. The lock cylinder, which contains the locks, is surrounded by a casing which is fastened to a frame, to which trunnions are attached. There is a partition in the casing, through which there is an opening, and into which the main shaft, which carries the lock cylinder, carrier, and barrels, is journalled. The main shaft is also, at its front end, journalled in the front part of the frame.

In front of the partition, in the casing, is placed a cam provided with screw surfaces. This cam is rigidly fastened to the casing, and is used to impart a reciprocating motion to the locks when the gun is revolved. There is also, in the front part of the casing, a cocking ring, which surrounds the lock cylinder, is attached to the casing, and has on its rear surface an inclined plane with an abrupt shoulder. This ring and its projection are used for cocking and firing the gun. This ring, the spiral cam, and the locks make up the loading and firing mechanism.

On the rear end of the main shaft, in the rear of the partition in the casing, is located a gear wheel, which works to a pinion on the crank shaft. The rear of the casing is closed by the cascable plate. There is hinged to the frame in front of the breech casing a curved plate, covering partially the grooved carrier, in which is formed an opening through which the cartridges are fed to the gun from feed drums. The frame which supports the gun is mounted upon the carriage used for the transportation of the gun.

The operation of the gun is very simple. One of the feed drums filled with cartridges is placed upon the gun; a man then turns the crank, which, by the agency of the gearing, revolves the main shaft, carrying with it the lock cylinder, carrier, barrels and locks. As the gun is revolved, the cartridges, one by one, drop into the grooves of the carrier from the feed cases, and instantly the lock, by its impingement on the spiral cam surfaces, moves forward, pushes the cartridge into the chamber, and when the butt end of the lock gets on the highest projection of the cam the charge is fired, through the agency of the cocking device, which at this point liberates the lock, spring, and hammer, and explodes the cartridge. As soon as the charge is fired, the lock, as the gun is revolved, is drawn back by the agency of the screw surface in the cam acting on a lug of the lock, bringing with it the shell of the cartridge after it has been fired, which is dropped on the ground. Thus, it will be seen, when the gun is revolved the locks in rapid succession move forward to load and fire, and return to extract the cartridge shells. In other words, the whole operation of loading, closing the breech, discharging, and expelling the empty cartridge shells is conducted while the barrels are kept in continuous revolving movement. It must be borne in mind that while the locks revolve with the barrels, they have also, in their line of travel, a spiral reciprocating movement; that is, each lock revolves once and moves forward and back at each revolution of the gun.

The feed drum has been lately applied to the gun by Mr. L. W. Broadwell. It takes the place of the feed cases previously used. The feed drum is a cylinder containing four hundred cartridges, and by its use four hundred shots can be fired, one man only being required to work the gun—that is, to attend to the feed and turn the crank. The ammunition is carried in the drums, and as soon as one is emptied it is removed and replaced by a full one, the change only requiring a few seconds.

The carriages for the gun are manufactured in Europe of wrought and cast-iron; those made at Colt's armoury, Hartford, Conn., are constructed of wood, and there is attached to them an automatic traversing apparatus, which, by the act of turning the crank, causes the gun to traverse through a maximum angle of six degrees. This angle can be diminished at will, or the apparatus can be thrown out of gear in an instant, and the gun be fired in one direction.

[1] Compiled from the "Science Record" for 1872. *A Compendium of Scientific Progress and Discovery during the Past Year. New York: Munn and Co.*

The use of these guns in connection with camels was, we believe, suggested by Col. H. H. Maxwell, R.A., Superintendent of the Cossipore Gun Foundry, whose experience in East India warfare led him to believe the adaptation would prove of the greatest benefit.

The Gatling fire-arms are made of three sizes, and one important advantage is the facility with which they may be adapted to the exigences of field-warfare in various parts of the world. The engraving exhibits the way in which the largest may be used on the backs of camels in India and other Oriental regions, where the absence of good roads and the peculiar features of the country render these animals most serviceable both for attack and defence. The feed drums before referred to are slung over the saddle, and when required for action can instantly be placed over the cylinder. The medium-sized battery is mounted on a horse in a similar manner; while the small size is fixed on a folding tripod, which is carried on a pole on the shoulders of two men, while others carry the feed drums slung over their shoulders.

History of the Gun.

The inventor of this wonderful arm is Dr. Richard J. Gatling, at the time of its discovery a resident of the city of Indianapolis, in the State of Indiana, but now of Hartford, Conn. He first conceived the idea of a machine gun in 1861, and is justly entitled to the proud distinction of being the originator of the first successful weapon of the kind ever invented. His first "battery" or gun was completed in that city in the early part of the year 1862, and his first American patent bears date November 4th of the same year. The gun was fired repeatedly during that year in Indianapolis, in the presence of thousands of persons, over two hundred times a minute, and its performance was regarded by military men as so satisfactory that the governor of that State appointed a committee of gentlemen of high standing and military experience to examine and report upon its merits. The committee performed the task assigned them, and on the 14th of July, 1862, made a highly favourable report to the governor, from which we quote the following brief extract:—

"The lock is certainly ingenious and simple in its construction, and fully protected from injury from any cause. The barrels are so arranged as to fire independently of each other, so that an injury to one does not affect the others. There are no complicated parts, and the common soldier can keep it in order as readily as he can his musket. It is so substantial as to endure without injury the same usage as an ordinary field-piece. The discharge can be made with all desirable accuracy as rapidly as one hundred and fifty times per minute, and may be continued for hours without danger, as we think, from overheating. Two men are sufficient to work the gun, and two horses can carry it over the field with the rapidity of cavalry."

This report and his own personal observation so impressed Governor Morton that, in a letter to P. H. Watson, Esq., Assistant Secretary of War, he recommended the weapon to the United States War Department as a "valuable and useful arm."

Manufacture of Guns in Cincinnati.

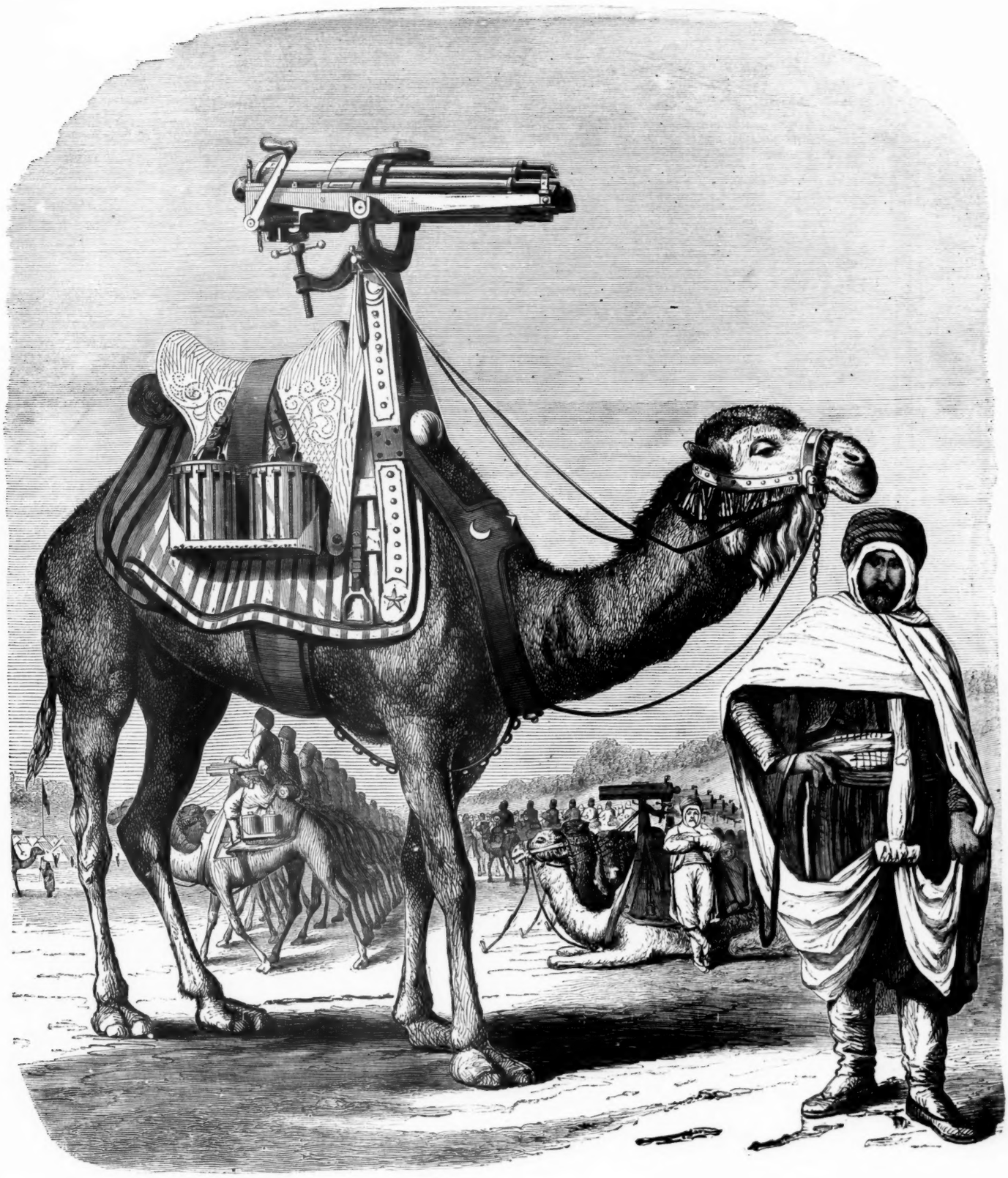
In the meantime Dr. Gatling had twelve of his guns manufactured in an establishment in the city of Cincinnati, Ohio, and fired them there repeatedly in the presence of army officers and the citizens generally. Among those in that city who witnessed the performances of the gun was Major-General H. G. Wright, then in command of the United States forces in that district, who also was so favourably impressed with it that, under date of March 11th, 1863, he wrote to Brigadier-General J. W. Ripley, Chief of Ordnance of the United States army, indorsing it as "possessing much merit," particularly "as a device for obtaining a heavy fire of small arms with very few men; it seems to me admirably adapted to transport steamers plying upon the Western rivers, where infantry squads are needed for security against guerilla and other predatory bands."

Trials by the U.S. Government.

Thus brought to the notice of the authorities in Washington, Rear-Admiral Dahlgren, Chief of the Bureau of Ordnance, ordered a trial of the gun, which took place in the Washington navy yard. The official report made to him on this occasion, bearing date May 20, 1863, concluded thus:

"The gun or battery has stood the limited test given it admirably; has proved itself to be a very effective arm at short range; is well constructed, and calculated to stand the usage to which it would necessarily be subjected. It is suggested that an improvement in the manner of rifling the barrels would be advantageous."

In accordance with the suggestion of this report, Dr. Gatling had a new set of barrels, with a change in the rifling, made and put in the gun; and it was on the 17th of July, 1863, again fired



THE GATLING GUN, ADAPTED TO INDIAN AND ORIENTAL WARFARE.

at the Washington navy yard, in the presence of a number of officers. The official report of this trial states that "the penetration of the Gatling battery was equal to that of the Springfield musket;" that the gun in its "mechanical construction is very simple, the workmanship well executed, and we are of the opinion that it is not liable to get out of working order."

These trials were so satisfactory to Admiral Dahlgren that he gave permission to commanders of fleets and squadrons to order what guns they might think proper for the service. But few guns were then furnished, however, owing to Dr. Gatling's inability to make them in quantities, and want of time to see naval officers and impress upon them their value and true character. But some of them did get into service before the close of the American war, and were used effectively in repelling rebel attacks upon the Union forces under command of General Butler, near Richmond, Va.

Various other Trials and Reports.

Trials in France, in 1867, proved the superiority of the gun over the famous mitrailleuse; but the late Emperor claiming the latter as his own, refused to recognize the merits of the American arm so far as to supersede the mitrailleuse by it.

The gun was thoroughly tried by the United States Ordnance Bureau, in 1865, favourably reported upon, and adopted.

In Vienna, in July, 1868, the Military Committee of the Austrian Government gave the gun a trial, which produced a very favourable impression. In this trial the gun fired 246 shots per minute, hitting 216 times, while infantry, firing 721 shots per minute, hit only 196 times.

At Shoeburyness, in September, 1870, the gun was tried in comparison with the celebrated nine-pounder India bronze muzzle-loading gun, the twelve-pounder Armstrong breech-loader field gun, the Montigny mitrailleuse, the Martini-Henry breech-loading rifle, and the breech-loading Snider rifle; the three last at short distances, up to 1,200 yards. Probably no arm was ever put to a severer test than that the Gatling gun endured on this occasion; yet the committee, embracing the highest military experts of the kingdom, made a most favourable report upon it, concluding with the following remarks:—

"The results of the recent inquiry have fully satisfied the committee of the expediency of introducing a certain proportion of these machine-guns to act as auxiliaries to the other arms of the service, and of the several designs which have been submitted for their consideration, including those that have been under trial, they are persuaded that the Gatling gun is the best adapted to meet all military requirements.

"To assist in defending such positions as villages, field intrenchments, etc., the committee feel satisfied that the small Gatling would be invaluable.

"For the defence of *caponnières*, for covering the approach to bridges or *têtes-de-pont*, for defending a breach, and for employment in advanced trenches or in field-works, where economy of space is of the utmost importance, the same sized Gatling would unquestionably be a most effective weapon.

"For naval purposes the small Gatling would apparently be well adapted for use in the tops of vessels of war, to clear the enemy's decks, or open ports; while for gun-boats that carry only one heavy gun, and for boat operations, the medium-sized Gatling would be most effective in covering the landing of troops, or for service up close rivers.

"The committee are also impressed with the effect produced by the medium-sized Gatling, 0·65-inch calibre, at long ranges as compared with that of a field-gun; but looking to the weight of ammunition required to produce this effect, and to the exceptional conditions under which the larger Gatling could be used with advantage in the field, they are satisfied that a gun is far preferable at long ranges, and consequently they do not recommend the introduction of the larger description of Gatling for land service.

"In advocating the introduction of the small Gatling gun, the committee wish it to be distinctly understood that they do not for a moment contemplate their supplanting or displacing a single field-gun, the proportions of which have been laid down by the best military authorities as indispensable for an army in the field.

"The characteristics of the two weapons are essentially different. Except against an enemy in the open, the fire of a mitrailleur is comparatively worthless, whereas artillery-fire will search out an enemy from almost any position, whether covered by trees, brushwood, earthworks, or houses, and at distances far beyond the range of a mitrailleur; but in the open, and at distances up to twelve hundred yards, there is reason to believe that the latter will be found the more destructive, owing to the rapidity and continuity of its fire.

"The committee have now the honour to submit the following recommendations:—

"The immediate introduction of the small Gatling gun for employment in the field.

"The guns to be mounted on suitable carriages adapted for two-horse draught.

	Cwts.	qrs.
Weight of a gun	3	1
Six drums, containing each 368 rounds = 2,208	3	2
Carriage and limber	10	0
Total . . .	16	3

"The whole of the carriages for these guns should be fitted with musket-proof shields, and range-finders should be used in connection with them.

"The exact number to be attached to each brigade or division, as well as the mode of horsing and manning the guns, to be left to the decision of the proper authorities. For the defence of *caponnières* and field-works, etc., to be mounted on carriages suitable for confined spaces.

"For the navy, to be mounted on such carriages or swivels as may be found best adapted.

"Should these recommendations be approved, the committee would suggest that, for a first instalment, fifty guns of the small calibre, for land service, and as many of the small and medium-sized guns as the Lords Commissioners of the Admiralty may consider requisite for the navy, be ordered from Dr. Gatling, pending the preparation of suitable plant, either at Enfield or Woolwich, for future production."

A subsequent exhaustive trial at Woolwich resulted in its adoption by the British Government.

Its merits, thus demonstrated by actual experiment, have secured its adoption by Russia, Turkey, Hungary, and Egypt, in addition to the United States and England.

Main Features and Superiority of the Gatling Gun.

The main features and superiority of the Gatling gun may be summed up thus:—

1. Its rapidity and continuity of fire.
2. Its simplicity—there is nothing complex about the gun.
3. Each barrel in the gun is provided with its own independent lock or firing mechanism.
4. These locks are made interchangeable, and are strong and durable; but should they get out of order, the gun is so constructed that any one or all of them can be, in a few moments, taken out and others inserted in their places, and so the gun can be kept in perfect working order at all times on the field of battle. It will not be denied that this is a feature of the greatest value, as the lock mechanism is the most essential part of a machine-gun, and is the only part liable to get out of order from use.
5. All the locks revolve simultaneously with the barrels, carrier, and inner breech, when the gun is in operation. The locks also have a reciprocating motion when the gun is revolved. The gun cannot be fired when either the barrels or locks are at rest.
6. The gun is made of single barrels, open at muzzle and breech, with space between them for the free circulation of air and radiation of heat, thus preventing to a great extent that heating and fouling of the barrels which, otherwise, the rapidity and continuity of its fire would cause.
7. The isolation of the barrels makes their expansion and contraction equal and uniform, and thus they suffer no distortion from these causes, as they would if massed together.
8. The barrels are open from end to end, and can easily be kept clean by the use of a swab or wiper.
9. The cartridges are loaded directly into the rear ends of the barrels; thus all leakage of gas at the breech is prevented.
10. The gun fires a shot at a time in rapid succession, and thus, by dividing the time used in rapid firing into equal parts between the discharges, and preventing an accumulation of recoil, it admits of larger charges, heavier balls, and consequently greater range.
11. This peculiarity of no recoil is of special value in the defences of bridges, fords, mountain passes, &c., which are frequently attempted during darkness, fog, or storm, as also in the smoke of battle, when the movement of the enemy cannot be accurately observed.
12. Firing a shot at a time also allows a lateral motion of the gun to be kept up during the time of firing, which result is attained in the Broadwell carriage upon which it is mounted, or by the Kinne attachment to the carriage manufactured at Colt's armoury, Hartford, Conn., by which the gun is traversed automatically.
13. No re-sighting and re-laying are necessary between the discharges. When the gun is once sighted, its carriage does

not move but at the will of the operator, and the gun can be moved laterally when firing is going on, as heretofore remarked, so as to sweep the sector of a circle of twelve or more degrees without moving the trail or changing the wheels of the carriage.

14. The continuous firing, a shot at a time, avoids all deflections of the balls.

15. As musketry fire, the small Gatling can be trained with far more accuracy and delicacy than small arms from the shoulders, and has no nerves to be disturbed in the din, confusion, and carnage of the battle-field, nor will the smoke of battle prevent its precision.

16. It requires fewer horses and men to serve it. The weight of the small Gatling is only three hundredweight; of the medium, five hundredweight; and of the largest sized, six hundredweight. Two men serve the first, and from five to seven men the last two. A still smaller sized gun, weighing only one hundred and twenty-five pounds, has recently been constructed at Colt's armoury under the supervision of Dr. Gatling.

17. Its great economy, not only in men and horses, but in ammunition.

18. The great safety in the transportation of this ammunition. The cartridge cases or shells for the larger Gatling guns are constructed of sheet metal which is $\frac{15}{100}$ of an inch thick; the heads are made solid, and solder is used in their bases. These shells can be re-loaded and fired from fifty to one hundred times. They are also waterproof, strong enough to stand all usage incident to the service, and are safer in transportation, are of less weight, and occupy less space, thus requiring fewer men and horses for their transportation and service than artillery ammunition. By carrying loading machines, with extra balls and powder, and detailing men to re-load the shells after they have been fired on the field of battle, a supply of ammunition can always be kept up in time of action.

19. The operation of loading is greatly simplified. There is no need of sponging, capping, priming, adjusting of fuses, cocking, &c. All that is required is to supply the hopper with the cartridges and to turn the crank, when a continuous stream of balls can be discharged.

20. The flanges of the cartridges have square faces in front, which enable the shells to be easily extracted from the chambers of the barrels, after they have been fired, by the improved extractors with which the locks are now made.

21. The great range of the large gun, equal for all practical purposes to that of the field-gun, and greater, in accuracy and precision, given to it from the use of the elongated leaden bullet, which has great specific gravity and small air resistance.

22. The projectiles of the large gun may be either solid shot, shell, or canister, like those of field artillery.

23. The balls of the Gatling gun ricochet for a greater distance than the shells or missiles of the field piece.

24. The feeding drums and feed cases of the gun can all be used with any gun of the same calibre.

25. The working parts of the guns are encased in the breech covering, so as to be entirely protected from dust and bad weather.

26. The largest sized gun, with a range of from two thousand to three thousand yards, can be taken apart, packed on mules, carried across mountains, and on its arrival at its destination can be re-assembled in a few minutes.

THE GREAT GAUGE QUESTION OF INDIA.

THIS subject has been found not only worthy of a long parliamentary debate, but the Institution of Civil Engineers has devoted its evenings for the last two months to the "Relative Advantages of the 5 ft. 6 in. Gauge or of the Metre Gauge for the State Railways of India;" and of such imperial interest does the subject appear to be, that the Prime Minister himself has honoured Great George Street with his presence—amongst a host of distinguished visitors who have scarcely found standing room. In this assembly the discussion has been nearly all on one side, the majority of the speakers being decidedly against a break of gauge. All the old stock arguments against transhipment have been taken down from their dusty shelves and furbished up anew for battle, which is only reasonable; but it certainly does appear curious that the very elementary questions of first cost and estimate should provoke such great conflict of opinion and be the subject of so much diversity of statement.

To begin with, Mr. Fowler and Mr. Hawkshaw, in comparing a 3 ft. 6 in. with a 5 ft. 6 in. gauge railway in the five items of land, earthworks, bridges, sleepers, and ballast, do not agree at all closely in their views of the savings which may be effected per mile. Mr. Fowler makes them £633 a mile, Mr. Hawkshaw £360. But Mr. Thornton, the author of the paper itself, contrives to sum up the total difference in favour of a metre gauge line at £1,000 a mile, a difference which every engineer must agree cannot be substantiated in practice except in very exceptional country.

There is one point on which all authorities seem to agree: that is, that the lines at present built in India have proved commercial failures, and that some alteration is imperative in future; and the question resolves itself simply in this: *Can* standard gauge lines be constructed cheaper than they have been advantageously, or must a narrower gauge be adopted to realize the hoped-for reforms?

Let us begin at the beginning. To do an equal amount of work on either gauge equal power is necessary, and for that purpose the same sized fire-box must be put to both engines. Now it is impossible to have the same sized fire-box on the metre gauge as on the standard gauge; hence, unless some exceptional means be employed on the former—such, for instance, as the Fairlie locomotive—there will be a disadvantage in the narrow system.

The answer to this is, that the broad lines have too great a calibre for the work they have to do—there is no occasion to employ large fire-boxes upon them. It appears that the little Festiniog 2 ft. gauge line in North Wales actually carries over 500 *tons* a day of goods, exclusive of its passenger trade; whereas the heaviest worked East Indian railway on 5 ft. 6 in. gauge takes only 800 *tons* (according to a speaker at the Institution); hence one must be very much over-worked or the other under-laden if gauge has anything to do with capacity.

Yet this is well known, that the wider the gauge the greater is the facility to the locomotive constructor as locomotives are now built; and there is no necessity for having a heavy engine because the fire-box is large or the gauge wide.

The next point is that of rolling stock, which is, after all, the most important. The carriages and the waggons are the rank and file of the railway; and as in a good army every soldier individually must be properly equipped and know his drill, so is it essential that in a well-managed railway the stock should not only be well designed and well built, but should be taken care of and looked after, which at the present time it seldom is—as if the managers considered it had but a subordinate part to fulfil in the enterprise, and would grind, and shake, and blunder along somehow, nohow, anyhow.

If you take a square rim of a box, six inches on a side, and place it on a table with one of the openings upwards and the other downwards on the table, it will be found it can hold 216 *cubic inches* of sand or corn. Now if another box like it be put alongside, that will hold also 216 *cubic inches*, *total* 432 *cubic inches*, and the amount of wood in one box is just half that in the two boxes. But suppose, instead of taking two boxes, one larger one be made having its sides a foot long each; there would only be twice the material that there was in one original box, or as much as would be in the two boxes; but the one big box would hold just double what the two small ones would, or just four times as much as the small one.

This is stated to show what is often forgotten—that the larger the vehicle in the abstract the less the quantity of dead weight to paying weight; that is to say, less wood and iron is involved where the carriages are big than where they are small, provided always—and this is the fallacy—that they are always loaded fully, which they are not.

Again, it is not in actual running that the whole of the requirements in a waggon consist; it is in its station life—in the facility with which it can be loaded or unloaded, shunted and moved about by a couple of men; and the bigger and clumsier it is the less can it be handled freely. Once upon a time very long cars—like those in use in America—were at work upon the *Monmouthshire* Railway in South Wales; they were mounted on four-wheeled bogies, and thus gave great facility in traversing the many 6-chain curves there are upon that line. But what has been the result? That the whole of these *Columbias*, as they were called, were sawn in two, and so shortened by one-half, and converted into ordinary four-wheel stock, which, although it was so manifestly disadvantageous on the curves and in its running life, yet more than redeemed these failings by its home or station qualifications.

The difference between the Great Western Railway broad gauge stock and the standard system stock of England has been very ably put by Mr. Slater, the manager of the Gloucester Waggon Company. He says:—"If a colliery proprietor applies to me for terms for hiring a 10-ton broad gauge waggon, or a

10-ton narrow gauge one, I should ask £18 a year for the former and £12 for the latter; and this applies to waggons that always take a full load. But if you apply the same mode of comparison to '*merchandise*' waggons, the result is still more striking." And he goes on to make the very astonishing statement that, "It is found in this country that the average load of a loaded waggon does not exceed 30 cwt. (this is exclusive of the empty mileage run by the waggons), which would halve it." And from this he observes that, "On broad gauge you have a dead weight of from 5 tons 10 cwt. to 7 tons for a paying weight of 30 cwt., whilst on the narrow gauge you have a dead weight of 3 *tons* 10 *cwt.* to 4 *tons* for the same paying weight."

No one who has ever stood at a country railway goods station can have failed to notice the vast disproportion between the consignment and the vehicle which has transported it. A few boxes of groceries, taken away easily under the seat of a tax-cart, have involved the detention for several days of a magnificent goods van weighing over 4 tons, and costing several hundred pounds. The steam-hammer has been lifted to crack a nut.

It is not that the narrow gauges, with equal speeds, give less relative dead weights to paying weights than the others, though it is clear to me that they do; but what is clearer still is that they do make each unit of stock smaller, and consequently more handy, less costly as one piece, and nearer approximating to the average unit of load. For instance, the Dunedin and Port Chalmers open goods waggons weigh each only 2 *tons* 7 *cwt.* Now, quite irrespective of what they carry, it is better to have two pieces of 2 tons 7 cwt. each than it is to have one of 4 *tons* 14 *cwt.*, because one man can move the two first singly, whereas two can scarcely move the second. Again, if a pin falls out or a breakdown takes place, much less capital is laid idle in the first vehicle than in the second.

But, it will be answered, would it not be possible to reduce the dimensions and weight of stock on the standard gauge so as to obtain a closer approximation to the practical unit? And the answer is only to be obtained by observing what has taken place, —that is the only test. On the 4 ft. 8½ in. gauge, by universal consent certain general scantlings have grown upon the gauge, and the weights follow those scantlings. The only way of effectively reducing the scantlings is by beginning at the gauge, which is the foundation of all; and you can no more put a small vehicle upon a big gauge properly, than you can expect Nature to create a horse with a pony's legs, or put a pony's body upon a horse's legs. Proportion is a subtle element, arrived at only by practice and time; and having arrived at it, it should be reverenced.

It is well known, in girders and structures that have to span across an opening, that the weights vary as the "squares" of the span theoretically, but in practice something *less*. Now, if we look at an axle, which is also liable to torsion, we find that the weight would be four times that of what it would be for a line of half the gauge and half the *weight*.

In India, Colonel Kennedy shows that the average bulk of the materials to be conveyed in commerce is from 75 to 80 ft. cube per ton. To convey this the waggons in use are, on the 5 ft. 6 in. gauge, 16 ft. long, 8 ft. wide, and 5 ft. deep, and carry 640 cubic feet, or 8 tons. The weight of such waggons would be 5 tons 10 cwt. This would make a grand total of 13½ tons for the weight of one unit of loaded vehicle. Now suppose two vehicles were employed to do this work, the amount carried by each being 320 cubic feet, or 4 tons, divided thus—vehicle 6 ft. 6 in. wide, 4 ft. 6 in. deep, and 11 ft. long.

Now, by remembering that the blow struck by a moving body —say, for instance, a wheel rolling over a diamond crossing—is directly as the product of the speed into the weight, it appears that for equal speeds the permanent way would be one half as strong only in the requirements for the second case as for the first. That is to say, if a 67 lbs. rail were employed for one, 33½ lbs. rails would be ample for the other; and as the sleepers vary in proportion to the work they have to do, half the material in sleepers would suffice. That is to say, if 360 square inches are found necessary in England for cross wooden sleeper roads per foot forward for 4 ft. 8½ in. gauge, and in America if 224 square inches suffice for the same gauge, certainly 180 square inches would be enough for a metre gauge line in India; for on the Norwegian lines 178 square inches are used for a gauge of 3 ft. 6 in.

Yet Mr. Fowler, in his comparative estimates of permanent way *from Kotree to Mooltan*, makes no difference at all in the weight of rail for the two gauges of 5 ft. 6 in. or 3 ft. 3⅜ in., but takes them both at 42 lbs.; whereas he makes a difference in the respective sleeper bearing surfaces of 50 per cent. between them. or for the first 350 square inches per foot run, and for the second 227 square inches; or, allowing 2,000, the same number of sleepers to the mile in both cases, he makes the wide gauge sleepers 8 ft. 6 in. long × 9 in. × 4½ in., and the small gauge ones 6 ft. 3 in. × 8 in. × 4 in., giving the first a surface on the ballast of 918 square inches, and the second a surface of 600 square inches. There must be some mistake here; either there is necessity for equal bearing power or there is not; if there is, then why reduce the sleeper? if there is not, why not reduce the rail? The same arguments apply to the ballast.

The fact is that the whole question is a simple one, and all resolves itself into the weight impinging at a certain point on the wheel's rim. "What is the impinging weight?" that is the *unit* to be dealt with; and having arrived at it, and kept it as small as possible, fix the gauge by it. Having decided that a weight of 2 tons on one wheel is the total amount which should be allowed at a maximum—that is to say, 8 tons for the whole loaded vehicle—of unit, we can (according to Mr. Carl Pihl, of Norway's, experience) reduce the weight of the rails to 30 lbs. only to the yard. ("Tracts Folio," vol. xv. Library Inst. C. E.)

Then comes the question, Can a 5 ft. 6 in. gauge waggon be built to weigh only 2 tons 15 cwt., and to carry *four*; or at maximum 3 tons, and carry five? To which the answer is, that experience has certainly proved to the contrary, inasmuch as it is not done, and would have no durability if done. That waggons in the northern districts of England used to be built for some weight of that kind, and that their construction has been gradually strengthened, only proves that the result of experience is that a light vehicle cannot well be put upon a broad gauge without wasting the advantages which that gauge ought to have.

Now let us for a moment review the arguments about that first requirement of all, the width of the vehicle. Col. Kennedy tells us that it should not be more than 1¾ times the gauge. Why not? What has experience shown us? First, that in England itself carriages are built 9 ft. 6 in. wide, which is more than double the gauge on the 4 ft. 8½ in.

That on the Festiniog Railway as much as thrice the gauge has been and is still employed, carriages of 6 ft. wide being placed upon 1ft. 11½ in. gauge. ("Engineering," vol. xv. No. 370, p. 82.)

Mr. Carl Pihl, in Norway, has for the last ten years been working with vehicles double the gauge.

The Pullman cars in America, those magnificent rolling hotels, are 11 ft. 3 in. wide, or nearly two and a-half times the gauge (really 2·4), and moreover they are 12 ft. 6 in. high, which is 2·65 times the gauge.

In Canada, on the Toronto, Grey, and Bruce Railway, which is 3 ft. 6 in. gauge, Mr. Wragge informs me that his vehicles are 8 ft. 6 in. wide; they are 7 ft. 11 in. clear inside, and allow a passage of 21 in. down the centre, and give a 3 ft. 1 in. seat for two passengers on each side.

These facts show that at the very least the Indian vehicles should be made no less than 11 ft. wide, if they are to do all the work they ought to do on a 5 ft. 6 in. base. Assuming them to be really made of that width, and to be fully loaded, they would present the most economical development of railway enterprise extant. But what are the facts? Let us take Col. Kennedy's own line, the Bombay and Baroda, and quote from its last report (see "Railway News," Nov. 2, 1872, p. 573), and the observations made upon it in the "Railway News":—

"The number of waggons constantly worked by the company was 2,512; of these not less than 1,154 were cotton waggons. The total quantity of cotton carried in the half-year was 4,108 tons, or 3½ tons per waggon for six months!"

Yet notwithstanding this astounding and incredible disproportion of result to the machinery employed, it seems that Colonel Kennedy insists that no railway waggon in India should have a less carrying capacity than 8 tons.

"In the corresponding six months of the last year (1871) the whole quantity of cotton carried was but 1,918 tons, or about one-half the weight of the waggons employed to carry it. If the cotton waggons made but one journey in the six months, and were loaded to their cubic capacity of 8 tons, they would carry twice the quantity conveyed over the line in the whole six months, and nearly five times the quantity conveyed in the corresponding half of the previous year.

"A similar state of things exists with respect to other portions of the company's business; there are 2,439 merchandise waggons of all descriptions) excluding cattle trucks) to carry 70,000 tons of goods, which give for the six months an average of less than 30 tons; so that if each waggon carried the 8 tons stipulated for by Col. Kennedy, it would require to make only four journeys in the half-year, and this would still leave 1,000 of the trucks unemployed for one journey."

The fact is that the heavy, lumbering "trucks do not carry one-tenth of their capacity." As Mr. Rendel pointed out in his recent report to the Indian Council, "*The principal cause of the high cost of working Indian lines is the insufficient loading of the trains and the consequent unnecessary mileage run.*

"The 8-ton trucks would do well if they had the load to

carry of eight tons; but as the average load is not one ton, common-sense would suggest that it would be economical to suit the trucks to the work they actually have to perform."

It appears also that the average traffic on the unfortunate "Bombay and Baroda" Railway amounted to only 733 tons a day, which was conveyed in six trains, or 122 tons per train, the heaviest grade on the line being 1 in 500. Taking an equal weight of load and waggon makes the gross weight 244 tons. As a contrast to this, we learn that our friends the Russians, whose aggressive attempts we are desirous of frustrating, on the 3 ft. 6 in. Livny Railway, with the narrow gauge Fairlie engines haul regularly 350 ton trains (of which the paying weight is 262 tons) up gradient, of 1 in 80 for 5½ miles.

The following facts are given on the authority of the secretary of the Livny Railway, which is an *Imperial line*, built for the express purpose of trying the narrow gauge system worked by "Fairlie" engines ("Railway News," Nov. 2, 1872):—

Gauge is 3 ft. 6 in.
Length of line, 38·15 miles.
Steepest gradient, 1 in 80 for 5½ miles.
Rails, 45 lbs. to the yard.
Rolling stock:—
2 tender engines weigh 17 tons empty.
5 double bogie Fairlie engines, 35½ tons empty, or 46 tons in working order.
Seventeen passenger carriages.
266 goods waggons.
About these waggons, we have for

	Tare.		Cwt. q. lbs.		Net load.		Cwt. q. lbs.
Platforms	105 poods	=	33 3 0	&	370 poods	=	119 1 12
Open waggons	125 „	=	37 0 20	„	360 „	=	116 0 16
Closed „	140 „	=	41 3 26	„	340 „	=	109 2 24
Brake vans	270 „	=	79 3 0	„	250 „	=	80 2 14

The waggons are 14 ft. long and 7 ft. wide, which gives a sufficient floor area for any description of traffic. The carriages are 21 ft. by 7 ft. 6 in. An average goods train weighs 350 tons in 50 waggons, the paying weight of which is 242 tons. The secretary says that the admission of sharper curves and steeper gradients effects a considerable economy in the earthworks and land occupied by the railway; the lighter weight and smaller dimensions of rails, sleepers, rolling stock and bridges produce great economy in the construction. The favourable proportion of paying weight to the gross weight, and the slight wear which the "Fairlie" engines and the light waggons occasion to the rails, are certainly conditions which will greatly contribute to the economy of the working of narrow gauge railways. At the trials of the Fairlie engines before the commission appointed to investigate the subject, one of the engines took a train of 61 loaded waggons of 410 tons gross weight at the rate of ten miles an hour from Russhy Brod to Verchovie, where the steepest gradients are situated, without stopping. The length of this train, exclusive of the engine, was 896 *ft.*

A word now on the subject of the unpressed cotton. Colonel Kennedy asks what we are to do with this bulky material. We can only say, what does he do with the *enormous* total of 4,000 tons odd he carries in six months on his own line?

He tells us it is 186 ft. to the ton; that is to say, his waggons, holding 640 cubic feet would take 3 tons 8 cwt. of it if not loaded more than 5 ft. high.

A waggon of half the weight and half the capacity would only take half this, of course. But what would be the objection to its doing so? The disproportion between paying weight and dead weight is the same in both cases; the advantage, if any, is in favour of the smaller stock, which does less mischief to the rails, having eight wheels instead of four.

This is the one sole argument for the broader gauge; and what does it amount to? Simply that you can do upon it what you can on the narrower base.

It is, however, important to note that the small waggons for the Indian state railways are not designed to carry the half of 640 cubic feet, but much more, viz., 430 cubic feet, and yet weigh only 3 tons each; that is to say, the latter, with about 55 per cent. of the dead weight, carry 70 per cent. of the freight of the former, or 5·4 tons against 8 tons; so that the account would stand much in favour of the *narrower* gauge.

Mr. Laing having brought forward his motion in the House on the evening of the 7th of March against a break of gauge in India, and five columns of the "Times" being devoted to the discussion which took place thereon, the subject has assumed such imperial interest, that every argument on either side should be most carefully brought forward and weighed in the balance. His chief argument seemed to be that in case of emergency the 1,200 engines and 36,000 carriages of the empire could not be employed upon the metre gauge length of 1,092 miles from Kurrachee to Peshawur, on which it was proposed to employ only 84 engines and 2,520 carriages; and he attempted to show that because continuity of gauge was essential to the success of the German armies in France, that the same conditions were equally essential to our success in resisting Russian aggression in India—totally forgetting that the territories of France and Germany were adjacent to each other, whereas those of the Russians and of our Indian possessions were separated by vast territories of neutral ground, over which the transport of armies would be a work of months, not days and hours. As Mr. Grant Duff justly remarked—"Could any human being picture to himself any conceivable concatenation of circumstances which would bring an invasion upon us as a surprise? Why, the very instant that a rumour came to this country of Russia's building a fort or moving a squadron of Cossacks a thousand miles away from our frontier—a number of well-disposed persons were even now seized with a fit of Russophobia, as if there were the slightest shadow of possibility of any attack being made upon us—every coign of vantage which our own frontier and the passes which looked down upon it, to say nothing of other points in advance, if they were wanted, would be perfectly easily and perfectly quietly taken into the safe keeping of our commanders. . . . ." Any railway, on any gauge which had ever been proposed, would enable us to send forward, at the very first whisper of danger, all and more than all the troops we could possibly spare from other parts of the country, and a great many of the best native troops we could use for such a war would in all likelihood not be brought up from other parts of India at all, but be recruited in our frontier districts; and, according to Mr. Thornton, "Even with rolling stock at the rate of one engine and thirty vehicles for every thirteen miles, it has been demonstrated by carefully and minutely detailed calculation, that in the course of a week 12,000 combatants of all arms, infantry, cavalry, and artillery, fully equipped and with a month's rations, could easily be moved from Lahore to Lukkur, or 11,000 from Lahore to Peshawur."

Mr. Grant Duff draws remarkable attention to the very small traffic of the lines in India, the East Indian Railway, the heaviest worked line of all, carrying only 840 tons of goods and 1,064 passengers in 24 hours, the average load of a train being 71 tons of goods with 89 passengers. According to General Strachey, the whole traffic of that railway might be carried on a narrow gauge line with an average of twelve trains a-day each way, such trains running half empty. Even the great objection of all, the break of gauge itself, on which so much stress has been laid, appeared to Lord Lawrence of secondary importance, by the side of the advantages conferred by an extended railway system, on a sound commercial and paying basis; for he justly contended that railways which ran into debt were worse than no railways at all. In this he simply echoed the sentiments of the late Viceroy of India (as quoted by Mr. Bourke, M.P.), that as regards India, "it was cheap railways or none at all, and I would rather do without railways at all than incur the risk of that normal increase of expenditure, and consequently taxation, which is our only real danger in India. It is a question of high policy, which I am better able to judge than the merchant or engineer. The 3 ft. 3 in. gauge will give us all we want for years and will save us hereafter from financial and political difficulty." No one can have read Mr. Bourke's excellent speech without feeling that it did completely clinch the arguments of the Under-Secretary for India; and that it also did justice to Mr. Fairlie, to whom, more than to any other man, the whole of this gauge question is indebted.

The cry is, Avoid break of gauge. Well, in spite of the opinion of the two late Governor-Generals of India, let us yield to that cry, and determine not to break the gauge. What will be our wisest policy? We have 5,000 miles of railway already built; but we have 10,000 more miles to build. Shall we continue in the error of our way, or shall we not rather endeavour to correct what has been done amiss? This seems to lead us to a very dire issue. It is no less than converting the whole of what has been done into metre gauge; or better still, into 3 ft. 6 in. gauge; as that is a simple dimension, and represents a difference of only 2 ft. from the 5 ft. 6 in. width.

In the consideration of this subject of conversion the words of the Chairman of the Bristol and Exeter Railway Company ("Times," 25 Feby. 1873), may be quoted with advantage. Speaking of his railway, he said, "The days of the broad-gauge were numbered. It would not be wise to make the change now, but he might state that the total cost of such an undertaking to them would be £31,000 (on 150 miles of double single line this would be £205 a mile). At that moment they had 300 waggons convertible at a cost of £3 to £5 each. They had three narrow-gauge engines, and eleven either convertible or being constructed to be convertible. The great source of cost would be the engines, some of which would cost £50 each to

convert, some £250 each, and some of the shunting-engines £100 each."

Here we have a practical illustration of the cost of such an undertaking under peculiarly difficult circumstances for the longitudinal sleeper road gives no such facilities for alteration as the cross sleeper arrangement in existence in India.

Mr. Fox, the engineer of the Bristol and Exeter Railway, writes that, taking everything into account, and including all the lines, whether in station yards or otherwise, I think that £160 to £180 per mile of single line would be a fair "estimate for converting a 7 ft. to a 4 ft. 8½-in. gauge."

And Mr. Owen, the Great Western Railway engineer, writes that for an Indian railway, laid on cross sleepers, £100 a mile would be a fair allowance for a single line.

Now it would not be possible, nor would it be necessary, to convert the whole 5,000 miles of the Indian system at once; such an operation might fairly be spread over ten or twelve years, which is the average life of a waggon, so that during that period all new engines and rolling stock should be so built as to be convertible; if this were done, a very liberal allowance would be £500 on an engine and £10 on each vehicle, this being double of the highest figure given for the Bristol and Exeter similar items; we should then have for India—

1,200 engines at £500 each . . .	£600,000
36,000 vehicles at £10 each . . .	360,000
5,000 miles at £160 per mile. . .	800,000
	£1,760,000

as the total cost of getting rid of the 5 ft. 6 in. incubus. That is to say, some £352 a mile—a fair and liberal estimate, considering that the conversion of the Bristol and Exeter Railway is taken at £205 a mile only.

Against this what would be the saving? Mr. Thornton has shown that the mean difference between Mr. Fowler and Mr. Hawkshaw's estimates gives a saving of £497 a mile, taking this as it stands, therefore, and multiplying it by 10,000 miles now required, we should have—

	£4,970,000 saved,
Less	1,760,000 cost of converting 5,000 miles.
	£3,210,000;

or three millions and a quarter saved, and a uniform suitable gauge throughout the whole of India.

But I venture to contend that this is not all. As above shown, if the sleepers can be reduced in size, so can the rail, and a 32 lb. rail would suffice where now 42 lbs. is necessary. Hence there would be on the new 10,000 miles a further economy of £250 a mile, representing—

	£2,500,000
Adding before	3,210,000
	£5,710,000 total saving.

All authorities, without a single exception, agree in the inappropriateness of the 5 ft. 6 in. gauge for the purposes of India; but they would rather perpetuate and extend it than suffer the temporary and local inconvenience of a change. What is the width which should replace it, if any? Shall it be 2 ft. 9 in., a yard, a metre, or as Mr. Fowler recommends, 3 ft. 6 in.? The reason why the Government adopted the metre was, that metrical weights and measures were to have been universally introduced in place of those now existing. This project having been abandoned, it became necessary to consider whether the 3 ft. 6 in. would not really be most desirable. It has one great advantage, that it is a clean round measure of *three and a-half feet*, not a horrible, complicated fraction of inches. Again, it represents exactly one foot off each side of the 5 ft. 6 in. width, or two feet exactly off the whole. But this is not all, though it is not much. The adoption of 3 ft. 6 in. would permit the use of the Indian width of waggons and carriages as it stands, that being precisely the same as that in use on the Toronto, Grey, and Bruce railway in Canada for the 3 ft. 6 in. width. It is well to follow something that has been done, or else the objectors, and their name is legion, will commence the absurd parrot-cry of "dangerous" experiments and the sacrificing of a nation's welfare in theories of "visionary" projectors; or we shall be told that we are daring to trifle with what may not be touched—the sacred ark of 5 ft. 6 in., which now costs the Indian tax-payers £1,600,000 a year to make up the deficit.

But, say the broad-gauge party, in future we shall not spend so much money on our broad-gauge lines as we have done; we shall make them "light." There is no greater mistake than a "light" railway. It means something cheap and bad, something which has neither capacity nor durability. It has been attempted in England and in other parts of Europe, and it has failed.

Besides, look at the country you have to deal with. It is not now the most fertile and the most populous places in India that you want to develope, but the poorest, the least prosperous. Hitherto your lines have been the main arteries of commerce, having the pick of the cities, and producing countries to back them; and yet with it all they cannot pay their 5 per cent. interest without nearly a million and three quarters annually from the State. You have only got one-third of the way through your task; two-thirds remain unaccomplished, and they are the *two* unprofitable *thirds*, which in the very nature of things cannot for many years hope to pay their way, and should lean for support on the surplus of the present lines—if any such existed, which, alas, it does not. Besides, 15,000 miles of railway in India is, even when made, absolutely nothing; it will leave districts as big as Ireland or Portugal without a single intersecting line. There are more than 15,000 miles of railways in the British islands, and yet there is room for more, especially in Ireland and Scotland. A very small study of the map will show that as British India is *eight or nine times* the area of the British islands, and has fewer roads and canals, that at least fifty to sixty thousand miles of railway will have to be constructed some day or other. And how hopeless must be their plight if they are all to be as bankrupt as those picked 5,000 miles already executed! An entire revolution must take place sooner or later; what has been done must be undone, and a new system must be inaugurated which shall have for its first task the reconstruction of what has been done wrongly.

But there is another and a still more serious consideration in favour of the narrow gauge. It is its overwhelming economy where mountainous districts have to be dealt with. I have hitherto avoided as much as possible going into estimates of the comparative costs. It is quite sufficient that all authorities do agree that there is an economy, although the differences between these authorities are great as to what that economy is. It seems they range through all amounts, from the lowest, of £200, given by Mr. Bruce, to the highest, £1,000, by Mr. Thornton. But whichever of these be correct, we have this substantial fact before us, that there is an economy even through the level valley districts of India. What, then, will be the case when we approach the hills?—for future railways in India will not traverse the valleys as they have done, but will have to penetrate right and left into the more inaccessible districts. Why, simply this: that the narrower gauge, by the employment of much sharper curves, enables the most difficult country to be opened at a cost very little exceeding that involved in traversing the plains; whereas, if the broad gauge be adhered to, with its 10 and 15-chain curves, the country is absolutely impracticable commercially. You cannot get at it, and therefore it is better to leave it alone.

In nearly every case of mountain or hilly country the line has to creep up the face of the mountain on sidelong ground, which is generally intersected by ravines; and the narrower the formation, and the sharper the curve, the better. For these purposes the narrow gauge is essential. Even this is not sufficient, although it greatly helps. The parallelism of the vehicles' axles, that is, their tendency to struggle to keep in a straight path when they run on a curved one, is what should be avoided if possible. The American long vehicles on independent trucks answer the purpose; but they have the great objection of being very heavy and *unwieldy*. "Grover's" system of flexible four-wheeled base enables the radiation of axles to be conferred upon ordinary vehicles, and destroys the objection of sharp curves entirely, giving railway carriages as much facility in going round corners as *omnibuses*.

To no country in the world has the 3 ft. 6 in. gauge been employed with more universal and undeviating success than in Norway. Hear what the engineer-in-chief, Mr. Pihl, says about it:—"On it can be combined a maximum of capacity, comfort, efficiency and safety, with the minimum of construction and working expenses. . . . If, on the other hand, the gauge is reduced to 3 ft. or less, stability, comfort, economy are sacrificed; while with the 4 ft. 8½ in., or greater gauge, expenses are multiplied in many departments, without corresponding increase of useful effect. It must not be supposed, however, that economy depends wholly on the gauge, but rather that it is the basis on which to proportion the various works and carriages necessary to carry the required amount of traffic. Thus, by adjusting the size of the locomotive in such a manner that you get, for example, a pressure on each driving wheel of not more than 3 tons to 3¼ tons, you are enabled to use lighter embankments, bridges and rails, and decrease the expense of repairs. I am often asked the exact difference between the cost of a railway on a gauge of 3 ft. 6 in. and 4 ft. 8½ in. It is difficult to make definite comparisons, as every railway is different. I believe, however, that it may be stated generally that the narrower gauge may be *built for, say, one-third less*." (His remarks here

would probably apply to Norway and similar rough countries.) "In working," he continues, "I can give a better test, by supposing a mixed train with three passenger coaches, with places for 96 passengers, but containing only 60 people, and 14 goods waggons, on a line with a ruling gradient of 1 in 100. In Norway the narrow gauge passenger coaches weighed 4·1 tons; goods waggons, 3·3 tons; and locomotives, 16 tons. Estimating each passenger at 140 lbs., and the load of freight at 70 tons, the total will be—

On the 3 ft. 6 in. gauge.

	Tons.
Three coaches, 4·1 tons each. Capable of holding 96 people, or 32 each.	12·3
Fourteen goods waggons, 3·3 tons each. Carry 5 tons each.	46·2
Sixty passengers, say	4·0
Load of freight	70·0
Engine	16·0
Total load of train	148·5

On the 4 ft. 8½ in. gauge.

	Tons.
Three coaches, 6·4 tons each	19·2
Fourteen goods waggons, 4·3 tons each	60·2
Sixty passengers	4·0
Load of freight	70·0
Engine	20·0
Total load of train	173·4

or 18 per cent. saved in locomotive power on the narrow gauge."

Such is Mr. Pihl's argument; and the story might be repeated from the experience of Russia, New Zealand, Brazil, and South America generally; whilst in the United States the universal adoption of the extremely narrow gauge has been the most emphatic verdict which has yet been pronounced on the question. Depend upon it, if a shrewd and practical people like the Americans decide so decisively one way, their decision should carry respect, if not conviction, everywhere else in similar situations.

But the Institution of Civil Engineers of Great Britain has declared otherwise, and for six weary evenings its theatre has resounded with the same cry, "Great is Diana of the Ephesians." It is better, we are told, to continue in the error of our ways than to attempt any reform; stick to the beaten 5 ft. 6 in. way. True, it has led to practical bankruptcy hitherto; true, it is admitted by its best friends to be a mistake; true, it has shown itself no less unworthy in Ireland than it has in India; true, the Russians and Americans have in principle abandoned anything approaching to it; yet by it we must be bound, and on it we must continue to travel and spend our money, till the last British regiment quits the shores of Hindostan for ever.

THE DINING ARRANGEMENTS OF THE HOUSE OF COMMONS.

IT is not generally known that attached to the House of Commons is a refreshment department which has absorbed a good deal of public money—money not to provide comestibles for the members, but to enable them to sit down in quiet and comfort to such dishes as may be obtainable on the spot.

The system has grown up in a singular way. In bygone years, when the dinner-hour for the well-to-do-classes was much earlier than at present, many members of Parliament dined before they went down to the House; while those who did not wish to adopt this plan reconciled their appetites to their legislative duties as best they could. In this state of matters Mr. Bellamy, a wine merchant in Parliament Street, obtained permission to establish a refreshment-room within the precincts of the House; he supplied not set dinners, but cold meats, chops and steaks, and light refreshments. When the structure was destroyed by fire in 1834, Sir Charles Barry included in his gorgeous design for the new building a dining-room, tea-room, kitchen, pantry, scullery, wine and beer cellars, &c. These rooms, with a few modifications of plan, were provided. Then arose an extraordinary conflict of opinions and authorities in answer to the simple question—Who is to manage this department? The Speaker, the Serjeant-at-Arms, and the First Commissioner of Works all had a voice in the matter; but no one of the three could act without the sanction of the other two. The plan eventually adopted was as follows:—The nation lent the rooms rent free; the furniture and appliances, even down to pots and kettles, were supplied by the House of Commons out of a fee fund, which precluded the necessity for an appeal to the national purse in the Annual Estimates; the foods and beverages were provided, cooked, and served by a purveyor who succeeded Mr. Bellamy, and who would have been puzzled whether to describe himself as lessee, steward, manager, or restaurateur; while the wages of cooks, waiters, scullions, and servants were paid partly by him and partly by the House of Commons. The renewal of working stock—*i. e.* pots and pans, kettles and gridirons, &c., proved to be an embarrassing problem; still more so the costly articles of plate, linen, glass, and crockery, and the rapidly-consuming items of gas, coals, and candles. Whenever any of these supplies were needed the purveyor sent in an application to the Select Committee which is every session appointed to watch over this peculiar section of the House; the Committee applied to the Serjeant-at-Arms; he applied to the Commissioners of Public Works and Buildings; and the commissioners ordered the articles to be sent in by the proper tradesmen. One year there was an application for "forty dozen table-napkins;" another year for "twenty-four dozen glass-cloths and coarse cloths;" another year for "new carpets for the dining-room;" another for "a tank for the preservation of turtle;" and all such appeals had to follow the same roundabout route.

The chief difficulty still remained to be solved. The rooms were provided; they were warmed and lighted; they were supplied with adequate furniture and fittings, utensils and appliances; cooks and waiters were engaged; the larder and the cellars could be periodically replenished by suitable purchases; but the purveyor never knew, and could not clearly know, how many dinners it would be expedient to cook on any one day. All was guesswork in this particular. Hungry men had to be provided for; but no one could foretell how many of these hungry men would present themselves at the hour when the hot and savoury viands were ready to be served up. It was, and still is, a commissariat problem really difficult to solve. On a full parliamentary night, when some great and exciting question is before the House, there is a certain period in the evening when the orators speak to (what are conventionally termed) empty benches, very few members being present. This period ranges from seven or eight to nine or ten o'clock—say about two hours, and is the members' dinner time. Some go home to dine, some to their clubs, some to the rooms within the precincts of the House; while the few who remain in presence of Mr. Speaker have perhaps dined earlier, or do not care to dine at all. The dull, prosy members have this period of the evening pretty nearly to themselves; by this means, the members generally are enabled to go to dinner without the probability of losing any particularly good speeches. Such being the custom, let us see how it affects the purveyor, the responsible head of the commissariat. He does not know whether there will be fifty or five hundred members present on a particular evening; whether the House will rise early or sit late; whether a large or a small ratio of the members present will honour him with their company to dinner. Added to these uncertainties, are those connected with "no House" and "count-out." If at four o'clock there are not forty members present, there will be "no House" that evening; every one leaves, and the doors are closed. If, say, at six o'clock, a member moves that the House be counted, and if the Speaker, after waiting a brief while, cannot count so many as forty members, the House is "counted-out," and no further business is transacted that evening. The party-leaders may or may not desire this summary mode of closing a debate by cutting it off in the middle; but the purveyor in the culinary regions cannot be otherwise than embarrassed. Say that he makes a guess that a hundred members will dine at the House on a particular evening; he makes preparations accordingly; when lo! a "no House" or a "count-out" reduces the number to twenty. How can he avert a certain loss under such circumstances? If honourable members ordered their dinners beforehand, and were bound to pay for them, the case would be otherwise; but this they seldom do; they rush down when hungry time arrives, and expect the wherewithal for a fairly good dinner with but little loss of time. No one could paint the true nature of the difficulty better than the purveyor did on one occasion in a letter to the committee:—"It has always been the wish of the committee, constantly expressed to members, that for their own comfort, and the better regulation of the dining-room, they should order their dinner a short time before it is required. But this has been found impracticable, as members themselves cannot tell when they may have the opportunity of dining. In consequence of this uncertainty, and at the end of an important speech and debate, every member who

wishes to dine proceeds immediately to the dining-room, and hence arises great confusion .... It has frequently happened that treble the number of a small day's business have dined with much greater facility and comfort when members have come in at regular intervals, than when the smaller number have come in unexpectedly, and all at the same moment. It is the numbers at once that make the confusion ; no notice, no intimation, but everything expected to be ready then and there, even though nothing has been doing for an hour." On the other hand, in reference to a particular year, "Many members are witnesses to my plentiful supply in preparing for a hundred and fifty or more, and only ten or twelve dining." Let any hotel-keeper, any cook in a private family, try to picture this state of things—the vexation in the first instance, and the loss to those who have to bear the cost ; he (or she, or they) would admit that the caterer for the House of Commons has no easy time of it.

Another matter which is settled in a remarkable way is the tariff of charges. This is laid down, not by any one of the three authorities above named, but by the committee ; and the purveyor must agree to it when he takes the contract. Once now and then a battle is fought on some disputed point between the members and the purveyor ; but the committee generally settle the matter. Some years ago a considerable item in the purveyor's profit was the supply of wine ; but the committee—which always comprises a good wine taster among its members—thought proper to take that matter into its own hands, and to increase the purveyor's allowance in other ways. There is generally something or other to say about wine in the annual reports of the committee. In 1869, for instance, the committee deliberated on a letter from a member of the House, "requesting permission for members to introduce a stock of their own wines into the House of Commons ;" but the committee resolved that "any increase in the number of wines admitted into the House is inexpedient, and would lead to great inconvenience." On another occasion it was resolved that "the supply of Hungarian wines be limited to four varieties, of which two shall be red and two white." Small matters these, some may think, for the greatest legislative body in Europe to attend to ; but it is only a committee that does this, and the committee seldom comprises members of great political and oratorical distinction.

The dining-room itself appears to have been, for a long series of years, a subject of quarrelling among the diners. It was too small, and was not well ventilated. As to its locality, only the initiated would know how to penetrate into it amid the labyrinth of a hundred staircases, eleven hundred rooms, and two miles of corridors which the over-grown, over-elaborated, but badly-lighted and inconveniently-arranged Palace of Parliament comprises. On an average evening the dining-room is large enough to accommodate the diners ; but on special nights it is far otherwise. In the first session of the Gladstone Administration there were two or three nights on which more than six hundred members were present in the House of Commons at once. True, they were only required to be there in such force when the division was about to be taken ; but there were two motives which prompted an early arrival to most of them. In the first place, by one of the minor rules of the House, a member can only retain his particular place the whole evening (by fixing his card in a little recess in the cushioned back of the seat) on condition of being present "at prayers" at four o'clock ; and, in the second place, there are often fine speeches to be heard from the leading members between five and seven o'clock or so. It may well happen, therefore, at seven or eight o'clock, that two hundred out of the six hundred hasten to the dining-room. And then it is that one of the troubles of the purveyor begins ; he cannot dine his two hundred guests without a good deal of jamming and confusion. Hence arose a demand for enlargement of the dining-room. So far back as ten years ago, the committee procured plans from Mr. E. M. Barry and Mr. Cubitt for a mode of effecting this improvement. A sum of £4,000 was named as the minimum cost for simply adding eight feet to the length of the kitchen and dining-room. Mr. Gladstone, who at that time had charge of the public purse, turned a deaf ear to the proposal. Year after year the proposal was made ; year after year it was refused by the Ministers for the time being. At length, foiled in a little, the committee made a very bold move. They instructed Mr. Barry to prepare a plan for alterations of a much more extensive character. He proposed to spend upwards of £20,000 in throwing two rooms into one, and adding other rooms to them, as a means of better accommodating the cooks and waiters as well as the diners. So unmanageable, however, is the structure which we owe to his father, that it lends itself with the utmost difficulty to any modification whatever. When the committee, in 1869, asked the question of Mr. Nicholas, the purveyor, concerning the mode of carrying out the alterations, his answers showed how curiously a watchfulness over his own interests (pardonable, and even necessary) influenced his decision. There was a proposition to have two lifts from the kitchen to the dining-room. He said, "If you make two lifts, of course you increase my labour ; and if you increase my labour of course you decrease my profit. If there are two lifts in the room, I have not the means of knowing what is going on ; I would certainly rather have one lift."

The alterations, or something approaching to a fulfilment of them, have since been carried out. A sum of £10,000 was appropriated by the House of Commons to this purpose in 1870, and in time for the session of 1871 the alterations were completed. The committee now report that matters are conducted in a much more satisfactory way. In 1871 we find there were 6,137 dinners and 5,359 luncheons partaken of during the session ; in 1872 the numbers were about the same, and Mr. Nicholas obtained "honourable mention."

A page of the "Practical Magazine" is not inappropriately devoted to this out-of-the-way subject, seeing that there are many problems, mechanical and monetary, to be practically settled in some way or other. The nation provides the rooms ; what equivalent of rent would this represent if the purveyor had to provide them? The nation (or some fee-fund which in effect belongs to it) provides the consumable articles, coals, candles, and gas ; what are these worth to him annually? The nation provides, and renews them when worn out or broken, furniture, fittings, utensils, and apparatus of all kinds. What is the average money value of these annually? What staff of servants would be necessary, for how many days (there are no sittings on Saturday, and only afternoon sittings on Wednesday), and for how many hours per day? What plan can the caterer or purveyor adopt to form even a remote guess at the number for whom to provide day by day? What will he do with the hot viands if the diners are only one-fifth or one-tenth as many as he expected? What tariff must he charge in order that he may balance all these contingencies and reap a fair profit? All these questions must be practically answered, or the scheme would fall to pieces. The "whips," as they are called, who are intimately acquainted with the usages of the House, and the ins and outs of honourable members, generally assist the purveyor with their opinion as to the probable number of diners on any particular evening ; but under the best auspices the venture is a somewhat precarious one to him. It belongs to the class of "circumlocutionary" matters in which responsibility is weakened by being divided.

THE SIEMENS DIRECT PROCESS FOR THE MANUFACTURE OF IRON AND STEEL.[1]

DR. SIEMENS commenced his paper by an examination into the amount of labour and the quantity of fuel required for the production of a ton of steel by the old indirect operations still practised to a small extent, and which comprise the use of blast-furnaces, puddling, cementing, and crucible steel-melting furnaces. He then alluded to the Bessemer process, and to the advantage which had resulted from the introduction of cheap steel due to that process. After which he gave a description of the Siemens-Martin or scrap process, and the Siemens or ore process, both of which offer great advantages for the manufacture of steel of a superior quality at a low cost. Dr. Siemens then stated, that since 1866 he had been engaged in the development of a process for the manufacture of iron and steel direct from iron ore, and described the apparatus which he had from time to time designed for attaining this end.

In the pursuit of this object, Dr. Siemens, in the year 1868, constructed at Landore a rotative furnace, for the reduction of iron ore into sponge, which was attached to an open hearth steel-melting furnace, where the reduced material was converted into steel by its fusion in a bath of cast-iron ; now, however, he effects the whole operation in the rotative furnace itself.

This rotative furnace is arranged as a regenerative gas furnace, in which air, intensely heated by means of regenerators, is introduced, in order to consume (immediately above the charge) the carbonic oxide, which is formed at a certain stage of the process, through the re-action of the oxygen of the ore upon the carbon mingled with it. By this means the waste of carbonic oxide which occurs in the blast-furnace is avoided.

As at present constructed, the rotator measures 7 ft. diameter

[1] Abstract of a paper read by Dr. C. William Siemens, F.R.S., at the meeting of the Iron and Steel Institute, held in London on the 30th April, 1873.

by 8 ft. 6 in. in length, is mounted upon antifriction rollers, and is provided with gearing through which quick and slow motion can be communicated to it at will.

Hitherto Dr. Siemens has confined his attention chiefly to the production of steel by this process, and in this he has been thoroughly successful, producing by such means a steel of superior quality, equal to crucible steel. He is now devoting himself to the production of wrought-iron, and an important feature of this process is the purity of the metal produced, notwithstanding the presence of objectionable matter in the materials employed. Thus, although coal containing on an average 8 per cent. of sulphur was used for admixture with the ores under treatment, the metal obtained, as was shown by the tables of analyses, did not contain above ·013 per cent. of sulphur, when ores free from that impurity were employed, and metal made principally from Cleveland ore was obtained with at most ·176 per cent. of phosphorus.

Samples of both iron and steel, giving evidence of the high quality of the metal producible, were made by Messrs. Vickers and Co, Sheffield; the Sample Steel Works, Birmingham; and the Landore Steel Company, Swansea. The last-named works, which were established when the scrap and ore processes were in their infancy, are now producing 1,000 tons of steel per week.

The rotator is closed by a swinging door at one end, is constructed partly of cast and partly of wrought-iron, and is lined with bricks made from calcined bauxite, a mineral peculiarly adapted by its refractory nature to resist the action of the scoria and the high temperature required. Having been previously heated, it is then charged with about a ton and a-half of iron ore, with the necessary fluxes, or admixture of other ores to form a liquid slag under the influence of heat, and is thereupon set in motion, and an intense flame being directed into it, in order to heat the ore thoroughly, carbon for deoxidation is introduced when the ore is on the point of melting. Under these conditions the metallic iron is soon precipitated from the molten ore, on which the slag is tapped off, and a greater speed of motion than before is given to the rotator to ball up the iron. A charge of 15 cwt. of wrought-iron may be thus made in rather less than three hours with a consumption of 25 cwt. of coal to the ton of metal produced, which is about one-half of the weight of coal required for making a ton of pig-iron in a blast-furnace.

THE WESTINGHOUSE BRAKE.

IN the last number we described in general outline a continuous air-brake, invented and manufactured by Mr. Westinghouse in the United States. This month we publish drawings of the mechanism of the apparatus. Our readers may remember that in the last article on this brake we explained that the contrivance consisted of an air-pump which forced air at pressure into a reservoir beneath the foot-plate of the engine; that two pipes were led from this reservoir beneath the carriages composing the train, and from these again went branch pipes to a cylinder beneath the centre of each carriage, which cylinder contained a piston and rod, which in turn acted on the brake blocks. If our readers will turn now to the drawings: fig. 2 shows part of locomotive and the framework of a carriage in sectional plan. E is the air reservoir, *f c* are pipes leading to the governing tap, controlled by the driver; *f'* is the pipe from this tap to conducting pipes H H' beneath the train; *k k* show the reservoirs in the india-rubber pipes. Figs. 5 and 6 show a skeleton view of the side and end of carriage frame with cylinder and brake levers; fig. 3 shows part of a carriage frame in plan, with cylinder and fittings; P P are cylinder and rod for brake, E' is a small reservoir which can be fitted when desired, and which, by means of a suitable pipe, supplies guard or passengers with a means of making signals to the driver. H H' are the pipes from engine reservoir; k^3 k^4 are the supply pipes for signal reservoir E'.

Figs. 8, 9 and 10 show in section the steam and air cylinders of the forcing pump for maintaining the pressure in the engine reservoir. On fig. 9 C is a piston and cylinder, *d* is a fitting on a rod *d* within main piston-rod D, and which has a notch which engages a pin on the plug valve *c* and turns the valve to and fro, admitting steam on either side of piston C, driving it back and forwards. The rod of this piston actuates spindle of the plug valves *a* of the main cylinder, thus admitting the steam alternately above and below main piston in cylinder A. When main piston has ascended, the solid part of D strikes end of *d* and pushes it up a little; this moves little plug valve and admits steam on one side of little piston C, which then moves *a* and admits steam over main piston, which descends and forces the air in the lower cylinder through valves *b' b'* into reservoir. When main piston is nearly at bottom of its stroke, the plate secured to main piston catches a collar on end of rod *d* and draws the rod down, thus again turning little plug valve C, and the little piston is moved back by the steam, and in turn moves *a*, admitting steam below main piston, and so on. Fig. 10 shows air cylinder in section through air valves; b^2 is the air section nozzle, fitted with rose cover to exclude solid bodies.

Fig. 11 shows complete plan of figs. 8 and 9. Fig. 12 is plan with cover removed. Fig. 13 is sectional plan cut between steam and air cylinders. Fig. 14 is section of brake cylinder to be fastened to the carriage frame. P' is a tapered socket secured to the piston-rod, within which the compression rod for the brake blocks rests and abuts on end of piston-rod; the socket preventing its shifting, while at the same time the piston and compression rods can accommodate themselves to the shifting motion of the carriages of the train.

Figs. 18 and 19 are views of the three-way tap controlled by the driver, and whereby he can put the brakes in action; or, by a quarter turn in the opposite direction, he can discharge the air in action on the brakes and set the wheels free again.

Fig 16. shows details of the union for joining the lengths of india-rubber tubing between each pair of carriages. Fig. 17 is a section of the entire joint. Fig. 21 is a section of the valve joint fitted from the pipe to the brake cylinder with the cross branch pipes; the valve is fitted to guard against the possibility of an inequality of pressure between the two pipes, so that the brake shall obtain the maximum pressure. In fig. 16 *l'* is a gun-metal ring put round the springs *l* to secure them; *k* shows the projecting collar behind which the bent ends of the springs catch; and on fig. 17 *k'* shows the nozzle which is pushed into the socket *n*. The two valves can be seen also in the section. When the joint is made good these mutually keep each other always open by the abutting of their stems, which are made of a length to do so; but should the joint be pulled apart, then either valve will instantly be shut by the pressure of the air on it.

It will be evident that every detail of this brake shows evidence of most careful thought and working out.

The air-forcing engine is beautifully contrived, there is nothing about it either perishable or costly, and it really cannot stop while the steam overbalances the air pressure. The reservoir being always full, not a second of time is lost in applying the brakes, or in removing them, either by the simple application of the three-way cock, which allows the air to exhaust at once when the driver desires. The jointing of the pipes along the train is the perfection of simplicity, and provides effectually against any evil results arising from the parting of the train while running, because the valves in the two unions at once close; the joint itself, too, while secure so long as the train keeps together, can pull apart should the trailing carriages break away, without fracturing any of the brake fittings; and not a small merit of Mr. Westinghouse's scheme is the excellent facilities it supplies for communication between guard and driver.

THE SLAUGHTER-HOUSES OF PARIS.[1]

NOW that the methods by which the food supplies of the metropolis can be best regulated are under the consideration of Parliament, and that a committee is about to sit on the question of private slaughter-houses (which were doomed in the Act of 1844), an outline of the system in operation in Paris can hardly fail to be useful to English readers. I think it is beyond dispute in the minds of the few men who have had opportunities of comparing the *abattoirs* of the French capital with the slaughter-houses of London closely, that the Paris system, which shows perfect order and cleanliness in every part, is the best, both for the dealer in meat and the consumer thereof.

To begin with the cattle market:—In the sixteenth century two cattle markets were established in the environs of Paris—one at Poissy for oxen coming from Normandy, the other at Sceaux for sheep from Brie and Champagne; and in 1646 the veal market was transferred to the Quai aux Ormes. These three markets, where the whole of the cattle destined for the food of the capital arrived on certain days, were in full activity until lately. That of Poissy has not lost all its importance even now.

[1] From an occasional correspondent of "The Morning Advertiser," who obtains his facts from Maxime du Camp's exhaustive work on "The Government and Life of Paris in the Second Half of the Nineteenth Century."

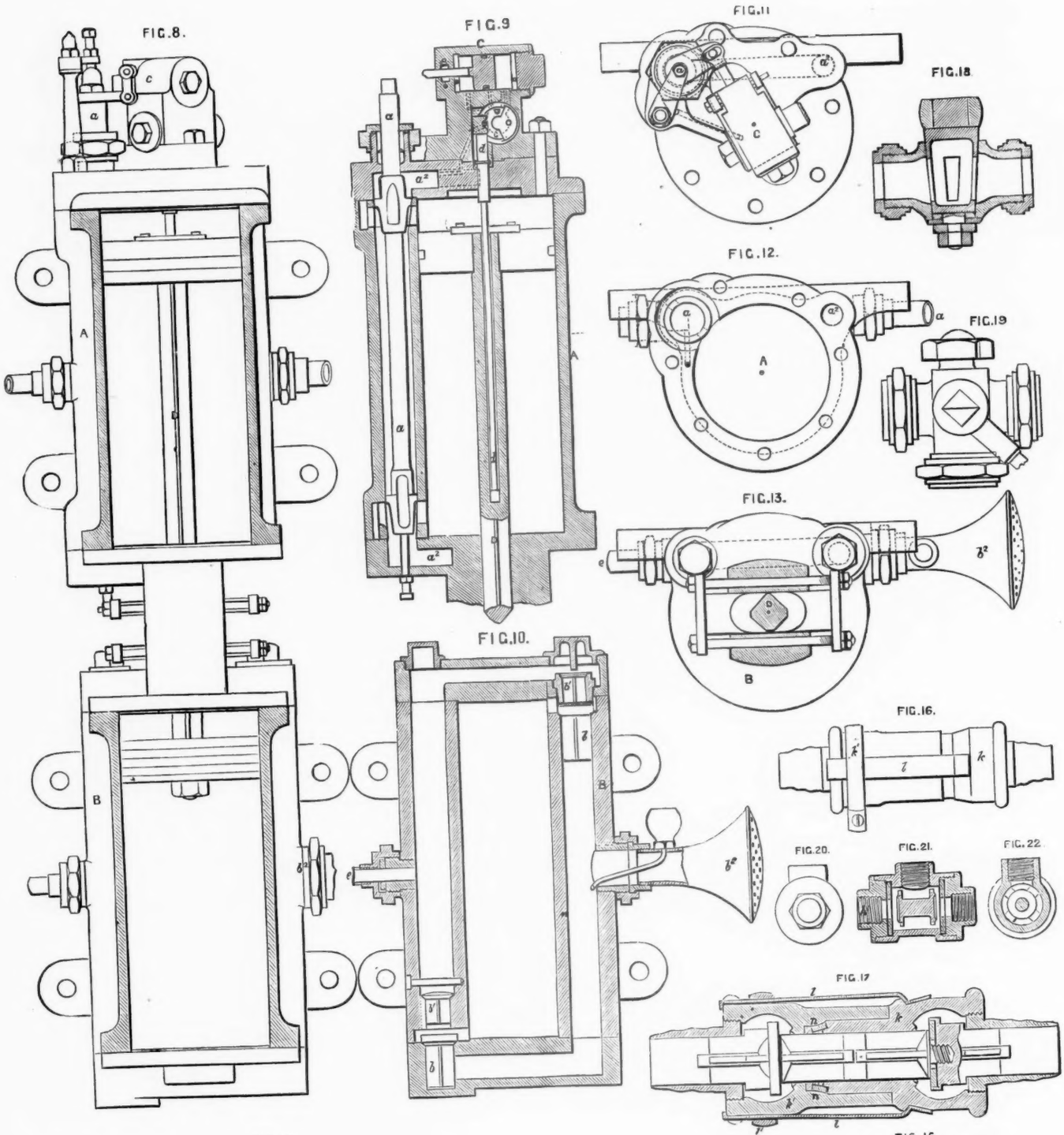

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FIG.9
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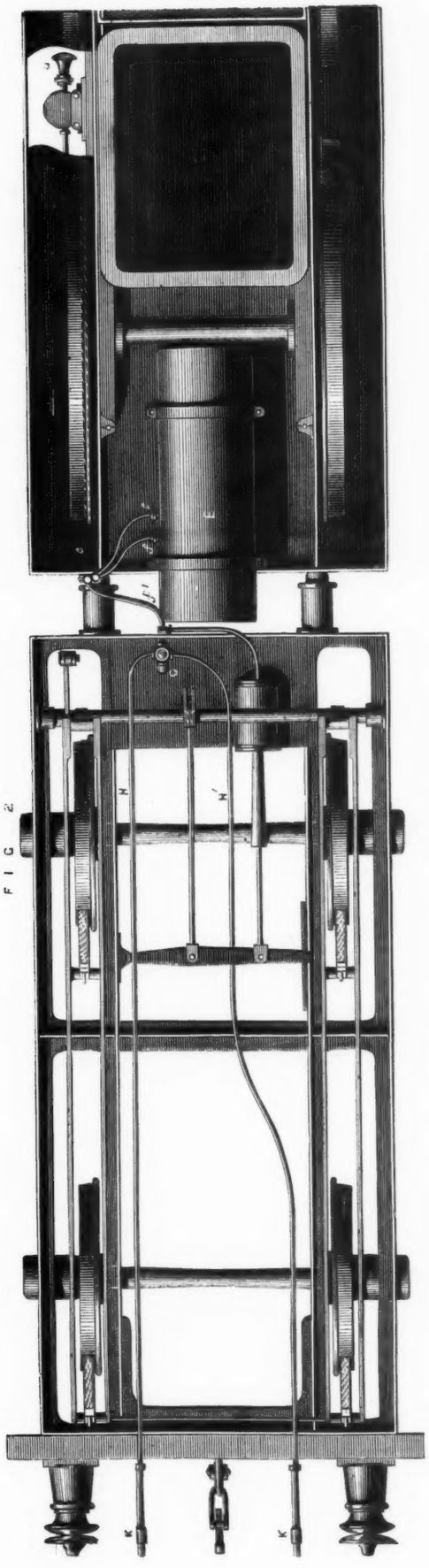
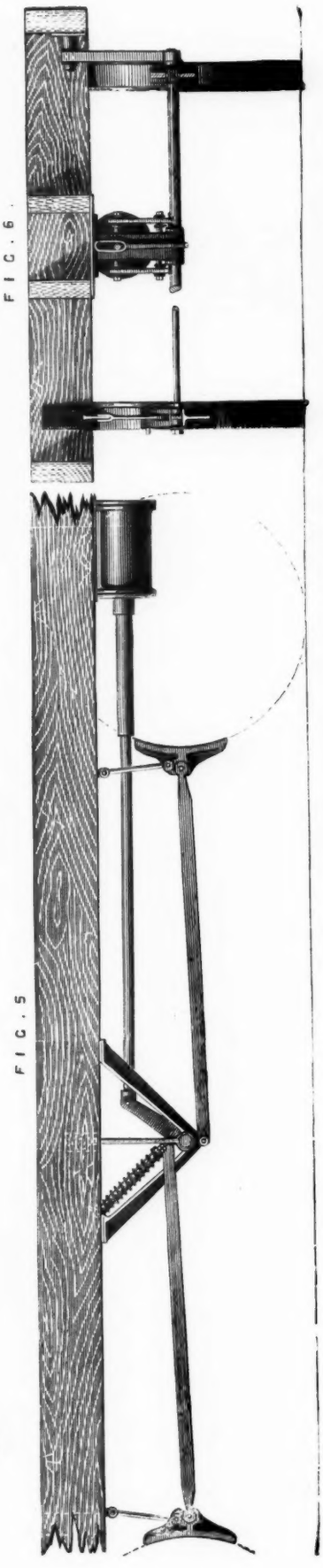
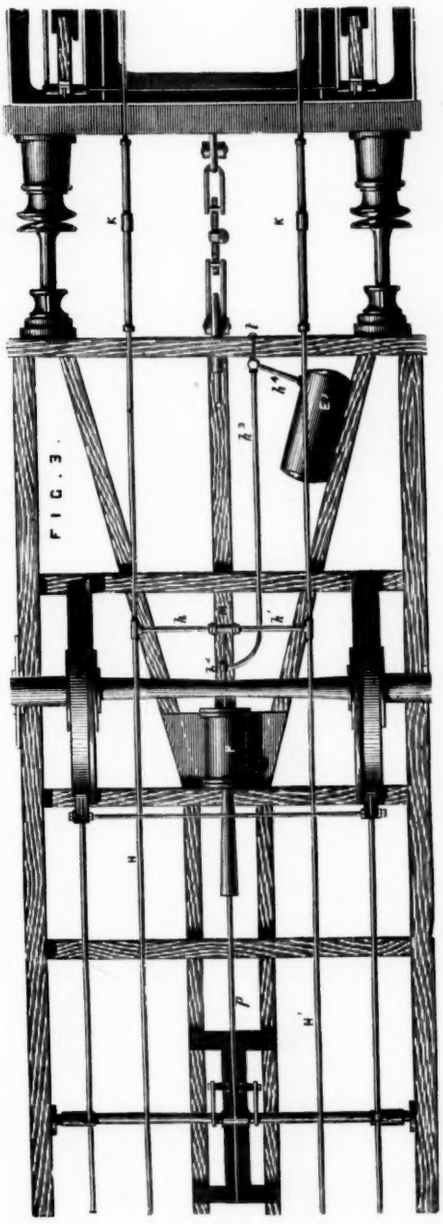






THE WESTINGHOUSE AIR-BRAKE.

An old traditional custom still brings some dealers to it. But on the 6th of April, 1859, a decree was published declaring the construction in Paris of a central cattle-market an object of public utility and urgency. It was thought, and with reason, that instead of seeking animal food far and wide, it would be simpler to bring the animals to the spot where they were to be killed, cut up, and consumed.

At La Villette, a newly-annexed quarter, near the canal de l'Ourcq, on a space of twenty-three hectares, the new cattle market has been erected, and it is probable that it will soon absorb the whole of the metropolitan cattle trade. In accordance with a contract entered into in 1864 between the Prefect of the Seine and one of the directors of the line of railway that girds Paris, a branch line has been constructed which brings the cattle from every province direct to the market. The rate of transport is fixed per head and kilometre at 10*c.* for an ox, 4*c.* for a pig or a calf, and 2*c.* for a sheep; the rates for loading and unloading are 5*c.* for a sheep, 20*c.* for a pig or a calf, and 50*c.* for an ox.

An administration appointed by competition for conducting the sales by auction has been intrusted also with the establishment of the market, the construction of the railway, and has a vested interest in the business of the market during fifty years. The administrators levy at the market gates a duty of 2*f.* 50*c.* each on oxen, 1*f.* for calves, 50*c.* for pigs, and 25*c.* for sheep; and further, every animal sold or not sold pays a certain sum for shelter for each night it passes in the market. This rate varies from 50*c.* to 10*c.*, according as the animals are oxen or sheep. The first market was held on the 21st October, 1867, on the new site, which had been inaugurated two days before.

Behind the gates erected in the Rue d'Allemagne, the opening of the establishment consists of a large field divided into pens, so constructed that the cattle may be easily counted by the officers as they pass in.

Spacious parallel sheds, three in number, and destined to shelter the animals during the sale, are divided by three broad streets, which enable the vehicles bringing cattle to stop on the quay of the market. These sheds are composed of glass roofs supported by cast-iron columns, and exceedingly cold in winter, are very hot in summer; but the animals do not remain there long, and, at least, are not exposed to the rawness of the weather. The middle shed, destined for the reception of bullocks, bulls, and cows, is 216 metres in length, and 87·20 metres in breadth. The one on the right, for pigs, is 100 metres less in length, and has an equal breadth; it is altogether similar to the shed on the left, where the sheep and calves are crowded into spaces unfortunately too narrow.

Beyond the sheds are the ox stalls and sheep stalls, surmounted by lofts, and disposed so as to form in the centre a courtyard, furnished with a tank. These erections are quite recent, and might be more complete and better arranged inside. The ox stalls, intended to contain 852 animals, are divided into several compartments. At certain times, when going in and out, the herds get mixed up together, occasioning much disorder and confusion, because each compartment does not open by a separate door. This is a serious inconvenience, and one which it would be very easy to remedy.

The defect does not exist in the sheep stalls, where each compartment has a separate door, which gives convenient egress and insures regularity; but the pens, containing 150 animals, have troughs so arranged that only 100 can feed. Two lateral troughs for such a large number of animals are plainly not enough, and there ought to be established a transversal trough, which, separating the whole pen into two equal parts, would enable each animal to reach his food easily. It is important that the animal, fatigued by a long journey on foot and by rail, should be able to recruit himself at the moment he is going to be killed and delivered to consumers. The calf pen is spacious, divided into large compartments, and furnished with an enormous boiler, which provides the calves with the tepid water indispensable to the preparation of their food.

The market is held every day. On Thursday, which corresponds to the old market days of Poissy and La Chapelle, the market is chiefly for pigs and oxen; on Monday sheep are predominant, this being the old market day at Sceaux. The market will hold 4,600 oxen and 22,000 sheep. When a drover has passed the gates with his herd he makes his declaration, and receives in exchange a number. Before the sale commences these numbers, all placed together, are drawn by lot, and indicate the reserved places. In this way there is no favouritism or trickery, and each dealer takes his chance. The bullocks, cows, and bulls are carefully separated.

Each animal bears a double stamp, serving as his full description. Bullocks are marked with scissors on the right by the dealer, on the left by the buyer, who places by the side of his figure the number of animals he has bought, so that the drover may always know if the drove is complete. The sheep are stamped with red or blue; pigs with a hot iron, which, however, is an inhuman method. The sales commence at eleven and finish at two o'clock. When the bell rings for the closing of the sales the drovers come up with their dogs; the different lots of cattle are marked, separated, and led into the stalls, or to the slaughter-house, or to the *barrière*, according to the purpose for which they have been bought.

An old custom, recognized by a decree of the 19th July, 1699, and by letters patent of the 1st July, 1782, and further confirmed by a decision of the Court of Appeal in 1841, grants to dealers, butchers, or others who buy bullocks, the privilege of having their money returned to them and the transaction annulled if the bullock die before the ninth day following the sale. This is a feudal custom, which is but ill-suited to the present time, and which should be abolished. The butchers should buy at their own risk, and only purchase animals in good condition.

In 1868 the cattle destined for Paris in the old markets as well as in the central one amounted to 289,654 bullocks, cows, and bulls, 179,276 calves, 193,166 pigs, and 1,514,285 sheep; a total of 2,176,381 animals sold and destined for the food of Paris.

Normandy sends bullocks from June to January; the Maine-et-Loire from October to March; the Nivernais, Charolais, and Bourbonnais, from March to June; the Limousin, the Charente, and the Dordogne, from November to June. The sheep of Germany arrive from September to January; those of the south, that is to say, from the region south of Orleans, from May to September; from Maine-et Loire, from July to November; from the Aisne, Oise, Somme, &c., from January to May; from Berri, from May to September; from the Soissonnais, from February to May; from Champagne, from August to September; and from the environs of Paris, between the harvest and the sowing season.

The most important departments in this respect number 32, among which the Calvados, Nièvre, Sarthe, Seine-et-Oise, and Maine-et-Loire make the most regular and the most considerable consignments. The whole of Europe, however, contributes to the meat provisioning of Paris. During the year 1868 Germany exported to Paris 629,342 sheep, Italy 1,950 bullocks, Spain 1,501 bullocks and 2,604 sheep, Hungary 178,280 sheep, the Tyrol 2,183 sheep, and Switzerland 1,239 calves.

Let us now pass from the cattle-market to the slaughter-houses, which are close at hand.

The animals bought at the market do not make a long stay there, but are promptly led to the slaughter-house, which now extends on the other side of the Canal de L'Ourcq over an area of 211,672 metres, and opens on the Rue de Flandres. The two establishments—the necessity of which was recognized by the decree of the 6th of August, 1859—were constructed simultaneously. The great central slaughter-house was opened on the 1st of January, 1867. The names of certain streets in the old parts of Paris indicate the quarters successively occupied by the butchers. Their trace may be found in the *Cité* by the church of Saint Pierre aux Bœufs, destroyed in 1837: again, near the Châtelet, by Saint Jacques la Boucherie, and by many other streets, of which the above are sufficient as examples. In early times cattle were killed everywhere—a slaughter-house was attached to each butcher's stall.

In spite of the different attempts made to remove beyond the walls the operation of killing, harmful to the population from every point of view, the old spirit of routine had still prevailed, and in the beginning of this century cattle were killed before the very doors of the shop where the meat was sold. No less than three Imperial decrees (February 9, July 19, 1810, February 24, 1811) were necessary to put an end to this intolerable state of things. These decrees ordered the immediate erection of five slaughter-houses in the neighbourhood of the Quarters du Roule, Montmartre, Popincourt, Ivry, and Vaugirard; but they were only finished at the end of 1818. They have partly disappeared now, making room for new roads, and are all to be replaced by the great establishment of the Rue de Flandres, which is joined to the cattle market by a bridge across the Canal de L'Ourcq.

As in the market, the animals are counted as they enter the slaughter-house, care being taken only to let one in at a time by the half-opened gate. Opposite this gate, beyond a large paved courtyard, are thirty-two buildings, divided into equal groups by three direct and three transversal streets, intersecting each other at right angles. These vast buildings contain stalls for the shelter of the animals; and 123 *échaudoirs*, *i.e.* places where the carcases are cut up after having been killed in the interior court, situated in the centre of the ranges of sheds. Both the sheds and the yards are carefully paved, and the ground, on an inclined plane, communicates with the sewers. Everywhere water is in abundance. The slaughter-house is frequented daily by some thousand slaughtermen and butchers.

The work begins, according to the season, at four or six in the

morning, and is continued until about one o'clock. At two o'clock the retail butchers come and make their purchases of the carcass-butchers, who buy the animals at the cattle market, have them killed and cut up, and sell them on the spot dead and dressed for the shops. 180 numbered carts, all exactly of one weight, carry the meat from the slaughter-house to the different quarters of Paris. Before going through the gate, they pass by the office of the octroi *employés*, and stop on a weighing machine, and thus the exact quantity of meat they take away is recorded. The octroi or town duties payable on the spot are 11·0735*c.* per kilogramme. Of this sum, 2*c.* are reserved specially for the liquidation of the cost of the immense buildings which have relieved the inhabitants of Paris of a pestilent nuisance.

Work is carried on daily, but Good Friday is naturally the busiest day of the year. The slaughtermen begin in the middle of the night, and often do not close their work before three in the afternoon. Though the old slaughter-houses still exist, the central establishment of the Rue de Flandres occupies the greatest number of workmen, and furnishes by far the largest portion of the meat consumed by the capital. In 1868, in the central slaughter-house, and in those of Villejuif, Grenelle, Beleville, Petite Villette, and Batignolles, 1,725,365 animals were killed, representing 107,577,968 kilogrammes of meat ready to be sold retail. The average weight of oxen was 350 kilogrammes, of cows 210, of calves 65, and of sheep 19. The average price of the meat bought at the slaughter-house was in 1868—for oxen 1*fr.* 34*c.* per kilogramme, for cows 1*fr.* 25*c.*, for calves 1*fr.* 65*c.*, and for sheep 1*fr.* 35*c.* Notwithstanding their magnitude, these operations are carried on with perfect order.

The ox is led into the yard with a short, stout rope tied round his horns. This cord is passed through a ring attached to the pavement and firmly tied. The ox bends his head, and the butcher, seizing a pole-axe, strikes one blow between the two horns. Without a cry the ox falls on his knees, and then on his flank. Two or three more blows effectually despatch him; his throat is then cut, and the blood is carefully received in large pails, and shaken about in order to prevent its congealing.

Calves are killed in the same way, and sheep by cutting their throats. It is difficult to form an idea of the skill and the rapidity of action of the butchers. In 48 seconds they will kill 20 sheep. When the ox, stunned and exhausted from loss of blood, no longer shows any signs of life, a hugh pair of bellows is inserted into an incision made in the skin, and the hide is thus easily separated from the flesh. Then the animal is opened, the internal organs removed, the limbs detached, and the head taken off. These operations demand half an hour's careful work from an experienced hand.

A saw is never used in the slaughter-house; the only instruments employed are the knife and an axe made wholly of iron, in order to avoid the contingency of the handle coming off. The slaughtermen handle it with marvellous dexterity. With this weapon, apparently so unwieldy, they sever from one end to the other the vertebral column of an ox with such precision that the spinal marrow is separated into two parts exactly equal.

Among the butchers are five Jews, who, in accordance with their law, never stun an animal, but always kill it by cutting its throat.

In general these butchers, whose trade is to kill, have a horror of seeing the animals suffer, and always do their best to despatch them at the first blow.

No part of a dead animal is thrown away; all is turned to account. At the slaughter-house itself, in the first court, is a building divided into two compartments furnished with large boilers, where the sheep's feet and calves' heads are prepared and made ready to be placed as we see them at the butchers' doors in pails of well water. The grease is carefully preserved, and a place has even been built for the purpose of melting it; but it does not seem yet possible to make use of it. The fat of sheep, when of good quality, is used in the making of candles. The feet of oxen furnish an oil used in clockmaking. The large intestines of the ox are bought by the pork-butchers; the small ones are sent to Spain, to become the cases of sausages highly prized beyond the Pyrenees; the thin intestines of sheep are made into harpstrings, the bones into animal black. All that is absolutely useless for anything else is added to the manure, of which about 16,000 francs' worth are sold annually at the central slaughter-house alone.

The Paris butchers are no longer what they were, a powerful corporation composed of a certain number of privileged families imposing their will on the city, as they did in the reign of Charles VI., when they took part for the Duke of Burgundy against the Armagnacs. In 1411, the Saint Yons, the Goys, led by their chief, Caboche, had enough influence to force the King to substitute on his flag the white for the blue. When the Armagnacs returned to Paris they did not spare such enemies; and the great boucheries of the Châtelet and of Notre Dame, which had become centres of formidable assemblages, were destroyed.

This was the real death stroke to the corporation. Later on, in February, 1587, Henry III. continued the work of destruction, and opened the trade to all those who showed themselves capable of undertaking it. But as with the bakers, so with the butchers, this supposed liberty was a mere illusion, and the law of 19-22 July, 1791, reserved provisionally to the municipal authorities the right of fixing the tariff of meat. This measure was still in vigour some years ago, and lasted, indeed, until the decree of the 27th February, 1858, which proclaimed the liberty of the trade; but, legally, the right of taxation still belongs to the municipalities, since the law of 1791 has not been abrogated.

The Paris butchers before attaining an open trade went through many difficulties, the latest being the system of categories, a complicated and elaborate piece of machinery, troublesome to understand for buyers, and the application of which created innumerable difficulties. The butchers succeeded so well at last in mixing all the categories up together that it was not easy to distinguish one from the other; even the most experienced were deceived, and so it came to an end. The number of shops was once limited to 500, but now the trade is thrown completely open to all who may choose to engage in it, and there is no regulation of prices. There are at present in Paris 1,574 butchers' shops, to which must be added 268 market stalls.

In order to encourage the provincial carcass butchers to profit by the rapidity of the railways and to send meat to Paris, in conformity with the *ordonnance* of police of the 3rd of May and of the 24th of August, 1849, a public auction has been opened for meat sent direct by the departments. This auction mart now occupies a portion of the *halles centrales*, and is divided into two distinct parts, one for wholesale and the other for retail transactions. Although but recently introduced, this sale by auction has already produced excellent results, and it increases in importance every day. In 1858 transactions were carried on to the extent of 10,000,000 kilogrammes of meat (in round figures), and in 1868 this amount had doubled, showing a total of 19,251,997 kilos.

The building specially reserved to this kind of transaction is well worth a visit. From one or two o'clock in the morning the meat, coming from the slaughter-houses or railway stations, is brought dressed, put in its place, hung up on hooks, and divided according to its owners into a certain number of lots for sale.

This done, each piece of meat having been numbered, the sanitary inspectors make their rounds, and with a stamp impregnated with blue ink, mark with a capital V (Va) each piece judged to be fit for food. Those lots which, having been examined, have been found to be diseased, are put apart. All meat which, notwithstanding its unhealthy aspect, still possesses nutritious qualities, is kept to feed the carnivora at the Museum of Natural History, which in 1868 received 134,341 kilogrammes. The rest is sprinkled over with essence of turpentine and is utilized for industrial purposes. The quantity of meat seized in 1868 as unfit for food amounted to 157,296 kilogrammes.[1]

When the meat has been stamped the mark is verified, and the lot placed in a huge pair of scales; a piece of paper, bearing the number of order, also indicates the weight, and is attached with a pin to the piece itself. When all these preliminaries are finished, but only then, the sale commences. Such are the various operations, all gone through under the eyes of competent authorities, by which Paris is supplied with wholesome butchers' meat. The consumption is very large. The quantity of butchers' meat sold in Paris in the year 1868 was 126,457,324 kilogrammes; of pork, 19,902,608 kilogrammes; showing for this year a consumption of more than 146 millions of kilogrammes. According to the last *Annuaire du Bureau des Longitudes*, the population of Paris was 1,825,274 inhabitants, including the garrison; the consumption of butchers' meat, then, per inhabitant was 69 kilos. 28 gr. yearly, and 189 gr. 8 centigr. per day of pork, 10 kilos. 90 gr. per year, and 29 gr. 8 centigr. per day.[2]

The dearness of beef and mutton has led to extensive speculations in horse-beef, which have had, however, only a moderate success. The poor know well that the horses killed and designed for food are old, used-up animals, worn out with labour and age, and that their flesh is consequently very poor food indeed. The masses have not been lured by the promises held out to them, and they are not to be blamed. An *ordonnance* of

[1] Some time ago the bad meat was simply buried or thrown into the river. It was found, however, in 1831, that the meat thrown into the river was recovered by the keepers of the small eating-houses, and used as food; the same practice was carried on when it was buried. At last the condemned meat, before being put under ground, was covered with lime, which made it impossible to offer it for consumption.

[2] The pork-butchers of Paris are 849 in number.

police of the 6th June, 1866, regulated the trade of horse-butchers. These butchers began business on the 9th July of the same year; on the 31st December, 1866, there were 22. There are at present about 20, all doing but little business. There are four horse slaughter-houses at Bicêtre, Gentilly, and Pantin. The number of animals put to death down to September, 1869, was 5,801 horses, 246 donkeys, and 37 mules. The average age was 14 years, and the total weight of the meat used 1,121,520 kilogrammes.

These establishments are also superintended by the inspectors of meat, who seize every unhealthy animal. In one single slaughter-house 24 horses were destroyed, and given up to the manufacturers of manure.

The horse-meat supplied to the butchers decomposes rapidly, being nearly always affected by the fatigue and toil that the animal has gone through. As people will not buy it readily, it is got rid of in the savoury guise of sausages, having the appearance and shape of those made at Arles, in Lorraine, and in Germany. This poor kind of *charcuterie* soon decomposes, and beomes uneatable. Moreover, at night, in order to escape the vigilance of the police, horse-flesh is carried to the poorer taverns, where it is served as *entre-côtes* and *filet*. At the horse-butcher's may be often found a piece of horse-flesh, larded, and ready to appear as *bœuf à la mode*. It is not, however, by mysterious rites that horse-flesh dealers will succeed in rooting out the old prejudice which exists against their trade, notwithstanding all efforts to destroy it. Many poor people, even in Paris, have refused tickets distributed gratis for horse-meat, and yet some races—the Kirghis of the steppes of Asia, for example—are very fond of horse-flesh, and prefer it to any other. Horse-beef is generally eaten in Sweden and Norway.

Now, the system of collecting cattle at one point on the outer line of Paris from every province of France, and of selling them there to the carcass butcher, who kills and re-sells them on the same spot—that is to say, within the range of one administration—is one which depends for its success on that habit and love of order which are peculiarly French. I will not pretend to determine whether or not the wheels within wheels of the Paris *abattoir* system would work as harmoniously in London as they have been revolving now for some years at La Villette. We are not, in an administrative sense, an orderly race; one attempt, for instance, to introduce the French *correspondance* system in omnibus traffic was a melancholy failure. Even the law which commanded every cabman to give his number to every fare was speedily found to be inoperative; and yet this precautionary regulation has worked easily and thoroughly in Paris for a long time past. Great drapery establishments like those of the Louvre, the Bon Marché, and the Coin de Rue, which are easily managed in Paris, although their organization appears to the stranger to be of the most complicated description and their departments of bewildering variety, work—*comme sur des roulettes*—in French hands. We have nothing like such establishments in England; and it is because I doubt whether such machinery as they involve would be successfully kept in motion in London that I feel uncertain as to the success of a single cattle market and slaughter-house for London.[1]

I am informed that a deputation of experienced gentlemen are on their way to Paris to inform themselves thoroughly on the cattle concentration, the slaughtering, and the distribution of meat over Paris, now in operation. I only hope they will extend their inquiry beyond La Villette, and be enabled to give evidence before the Select Committee of the House of Commons that is to be appointed on the universal habit of administrative order which is the foundation of the success of the French *abattoir* system.

At any rate, the necessity for some reform in London slaughter-houses is evident. Only the other day a drunken ruffian was sentenced to fourteen days' hard labour, by Alderman Owden, for the most abominable cruelty to pigs. This man, who was a slaughterman, in the employ of a butcher in Hosier Lane, was discovered by an officer of the Royal Society for the Prevention of Cruelty to Animals, armed with a loaded stick, in a pen of pigs. This instrument, it appears, is used for stunning the pigs before they are killed. He was drunk, and was seen by the officer in question to strike one pig seven times before he felled it. Another pig he struck eleven times, "literally smashing its nose, eyes, and mouth." When about to be apprehended the brute threatened to slaughter the officer as he had just slaughtered a hog, and he was supported in his threat by a fellow-slaughterman, who appeared to be only second to him in brutality. It seems that any inspection of private slaughter-houses is attended with some danger to the inspectors; and this we can readily believe, if London slaughtermen are generally even remotely like those of Hosier Lane. M. Maxime du Camp's evidence goes to show that thoroughly-inspected and well-regulated slaughter-houses do not deprave or brutify the men who work in them, and that the man whose sad occupation is that of killing animals for human food may remain keenly alive to the pain he has to inflict, and even anxious to make it as little as possible. This evidence will have very great weight in all humane minds.

[1] The experience in Scotland, derived from the splendid *abattoirs* established in their suburbs by the authorities at Edinburgh, will be useful in considering this question.—ED.

BRONZE VASES INCRUSTED IN SILVER.

By MM. CHRISTOFLE AND CO., PARIS.

WE print on the opposite page illustrations of several fine specimens of vases in bronze, incrusted with silver, manufactured by the process invented by MM. Christofle, Paris. The severe style of art here illustrated is to be remarked—enhanced as it is by the colour of the material employed. The decoration is truthful; there is an abundance of flower-work, and of network as delicate as a spider's web. The resemblance, besides, is perfect. No doubt, a Japanese expert might detect the European origin of the pieces; but for us there is no difference between these articles we now illustrate and those which we have seen in museums and at sales. Besides, what is more likely than that these same pieces may be highly esteemed at Yeddo or at Pekin, or taken one day for genuine specimens of the antique?

OTTO of Rose.—(*Pharm. Journ.* 3rd series, ii. 1051.) The rose-oil which Europe consumes at present comes almost exclusively from the southern slopes of the Balkan, where, in some one hundred and fifty places, the ingathering of the rose blossoms and the manufacturing of the rose-oil takes place. The quantity of oil which is produced in the south of France is very unimportant as compared with the quantity of the Turkish produce.

The most important Turkish districts where this valuable article is produced are Tchirpan, Philippopolis, Carlova, Lenizaghra, and Kizanlik: this last is the most important of all.

The roses planted in the basin of Kizanlik have light red blossoms. They are planted in rows like the vine. Sometimes roses and vines are planted intermingled on the same plot. The most important species of roses planted there are *Rosa damascena*, *R. sempervirens* and *R. moschata*; the first of these is also planted in the south of France; the last mentioned, which has a slight musk flavour, gives the chief material of the produce of the Indian rose-oil.

The roses are gathered in their blossom state during the month of May, and are subjected to distillation together with their green calyx leaves. 5,000 pounds (German weight) of roses give by careful distillation 1 pound of oil.

The so-called freezing degree, that is, the degree of temperature when the separation of the solid parts takes place, varies with the oils of Kizanlik between 8 to 16 degrees Réaumur, equal to 50 to 60 degrees Fahrenheit. The best oils get solid or stiff at these temperatures; they come from the colder mountain districts, whereas the oils from the warmer localities get solid at 12 to 16 degrees Réaumur, equal to 59 to 68 Fahrenheit. These oils, marked strong oils, have a less delicate flavour, and are preferred by ignorant traders.

It is evident that such a valuable substance as the rose-oil is very much exposed to adulteration. The adulteration takes place most extensively at the home of the oil, where also the substance for adulteration is produced on a large scale. This article, also an ethereal substance, is called in India "rosia-oil," in Egypt "idris-oil," and in England "ginger-oil." It is distilled from species of *Andropogon* and *Cymbopogon*.[1] The idris-oil is sometimes called "geranium-oil." Among the data furnished by Mr. Kasselmann is one that the distillers often adulterate the rose-oil with geranium-oil which is imported from Alexandria. This is but idris-oil exported from Bombay.

[1] *Cymbopogon* is synonymous with the genus *Anatherum*; the latter is the name used. Both *Anatherum* and *Andropogon* belong to the order *Graminaceæ* (section *Andropogoneæ*).

BRONZE VASES INCRUSTED IN SILVER—CHRISTOFLE AND CO.

THE PLOUGH, ITS HISTORY, CONSTRUCTION, AND MANAGEMENT.

IN the article in last number of this Magazine we traced the history of the Plough from the date of the earliest records up to the period when the Scotch mechanic Small (?) took the implement up and brought to bear upon it his mechanical skill and the practical knowledge which he evidently possessed as to the work which it had to perform, and how its several parts aided in that work. As his model was the Rotherham plough (see fig. 12, p. 271), the Small plough was the model which the majority of succeeding makers took as that upon which they based their alterations, which in many cases were not improvements, while in many they were really so. From an examination of this plough, which we have illustrated in fig. 14, p. 271, &c., the reader will perceive how closely in general aspect and technical features the plough of the present day approaches to it, as may be seen in fig. 15, which is an elevation of a "Swing Plough," of one of the best makers of this form.

Ploughs may be divided into three classes—the "swing," "wheel," and "turn-wrest." The two former possess many features in common, while the latter, arranged to perform work of an essentially different character, has peculiarities of construction which the former do not possess. These we shall glance at in their proper place. Deferring to a future part of our paper the consideration of the difference in arrangement of the two classes, "wheel" and "swing" ploughs, and of the assumed advantages of the one over the other, according to the views held of their practical working capabilities, we shall now notice the principles involved in the construction of the features peculiar to both forms.

"The plough," says Mr. Hindley in his Prize Essay published in the "Journal of the Royal Agricultural Society," vol. i. p. 141, "is, mechanically speaking, a portion of a screw or a curved wedge, forced forward horizontally, with which, in the first instance, the surface of the soil is cleft to a certain depth and width, while the wing or mouldboard is so constructed as to lift and deposit the separated portion at a given angle." This description involves two points for consideration: the "cutting" parts, and the contrivance for "laying over the slice" at the proper angle, obtained by their aid.

The cutting required is of two kinds, vertical and horizontal; the former divides the slice from the adjacent soil, entering from the surface; the latter, the slice from the subsoil at a point a certain distance below and parallel to the surface. The former gives the width of the slice—which is technically called the "furrow slice"—and is performed by what is called the "coulter;" and the latter the depth, which is performed by the "share."

The "coulter" *d*, fig. 15, is in fact a strong knife secured to the frame *a a* of the plough, so as to maintain a certain angle with the surface of the soil. Towards the "land side" it is perfectly flat, while on the other, or "furrow side," it is generally made rounded or tapered on the back to give the necessary thickness and strength. The angle at which it is placed is usually 55 deg., but this varies according to the peculiarities of the soil in which it works. The methods of fixing the coulter to the frame and of adjusting the angle are numerous, varying with the notions of the makers; the most usually adopted methods we shall hereafter describe.

The share *f*, fig. 15, is placed at the fore part of the sole or slade *g g*, on which the plough rests while moving along the soil. It is made of wrought-iron usually in Scotch, but of cast-iron in English ploughs. Robert Ransome introduced as early as 1803 a method of preparing shares of cast-iron, by which the under side was case-hardened to the thickness of one-eighth, or one-sixteenth of an inch. "This part, from its hardness, wears very slowly, while the upper part of the share grinds more quickly, thereby producing a constant sharp edge on the under side. The land side point of the share is also hardened in a similar manner, which prevents it from wearing so fast as it would otherwise do at that part—a tendency to which all shares are more or less subject." (Ransome's "Implements of Agriculture," page 18.) The pitch or inclination of the share towards the point varies for the work to be performed; the pitch being greater for hard lands. The formation of the point also varies. For stony land it is tapered off to a point, while an angular edge is better for softer soils. The methods in use for varying the "pitch" of the share in the most approved form of ploughs will be described in the paragraphs devoted to that part of the implement.

The "cutting" portions of the plough being now described, we have next to notice its second and most distinctive feature—the "mouldboard," by which the slice—cut by the coulter and the share—is turned over at the proper angle. The mouldboard, as remarked by Mr. Pusey, "which, raising each slice of earth (furrow-slice) from its flat position gradually through an upright one, lays it over half inclined on the preceding slice, is *the* essential acting part of the plough." It should perform this special transfer of a very rough material with an equal pressure both crossways and lengthways. The true shape is founded upon mathematical laws, but as in a somewhat similar case of displacement, that of water by the bow of a yacht, it is doubtless best determined by actual trial. The test of perfection according to some authorities—and these we may say *were* at one time the great majority of English makers and agriculturists—in the work of a plough, is "that the furrow-slice shall lie, after being turned over, in a perfectly straight line, not only unbroken, but even uncracked." ("Jury Report of Great Exhibition," p. 225.) But upon this test we may have yet something to say, as more recent views have tended very considerably to modify it, if not to show its inaccuracy, in view of what are considered the requirements of modern culture. From what we have said, it will be seen that the immediate object of ploughing is to turn over and bring in the grass, weeds, &c., on the soil, and by inverting, to cover them up, and to prepare the soil for future pulverization by the action of the harrow, or cultivator, and the influence of the atmosphere. This opinion, as just now hinted at, is in contradistinction to that held by those who think the immediate office of the mouldboard is a double one—the laying over and the pulverizing of the soil at one operation.

From the important part the mouldboard performs in the arrangement of the plough, much attention has been paid to methods by which its true form could be ascertained. It is evident, however, that the varieties of soil met with in practice will very materially modify the conclusions arrived at from theoretical investigations. Thus, from the short soils having little cohesive properties, a short mouldboard with a convex surface is required, while for the clayey soils a long mouldboard with concave surface is found to act best. It is from the general peculiarities of the soil that short mouldboards are most used in Scotland and long in England; we shall see also, as we proceed, that short, abrupt, convex mouldboards modify, or tend to modify, the form of the furrow slices they turn over. "Were the circumstances always the same, there can be no question but that the mathematical form of the mouldboard would be preferable to all others; but under circumstances so various, the plan hitherto adopted has been to prove by experience and practical operation the form best suited to different lands, under an average depth and width of work, keeping as nearly as possible to the principle of the wedge, as necessary for the proper lifting, turning, and laying over the soil. Provided the mouldboard be made so that the work while in operation be properly performed, a good practical criterion as to its figure will be found in the evidence of friction it has undergone; and this, with the fine cast metal now in use, can be determined to a nicety. If on a given soil the mouldboard becomes uniformly brightened—if the mould appears to slip with light friction, and with the same pressure from one end of it to the other—it cannot be far, if anything, out of its proper shape for the purpose intended. And yet if the same mouldboard be used on some other lands, it will immediately show its inapplicability to them by the soil adhering to it in parts, not slipping well through it, and thus evidencing a want of uniformity in its general friction. Therefore, considering that neither depth nor width of furrow is always the same, and that scarcely one circumstance affecting its use is unvarying, it is difficult to find a rule which shall aptly suit these changes." (Ransome's "Implements of Agriculture," p. 27.) This author, however, while holding these opinions, does not presume that this "unvarying rule" cannot be found; and amongst the theories promulgated, is inclined to prefer that of Mr. Rham, the well-known agricultural writer, and author, we presume, of the article "Plough," in the "Penny Cyclopædia." This theory we shall afterwards refer to. The Marquis of Tweeddale, whose practical researches in agriculture and experiments in the working of ploughs are so well known, thinks the following the best mode of procedure to ascertain the form of mouldboard. For this we are indebted to the very practical work of "Deep Land Culture,"[1] by Mr. Stephens. The description, we may here note, refers to the mouldboard for the deep land plough. "It was conjectured that a convex form of mouldboard would effect the purpose, and it was constructed in the following manner. A mouldboard of convex shape was

[1] "Yester Deep Land Culture," by Henry Stephens, F.R.S.E.; Author of the "Book of the Farm." Blackwood, London and Edinburgh.

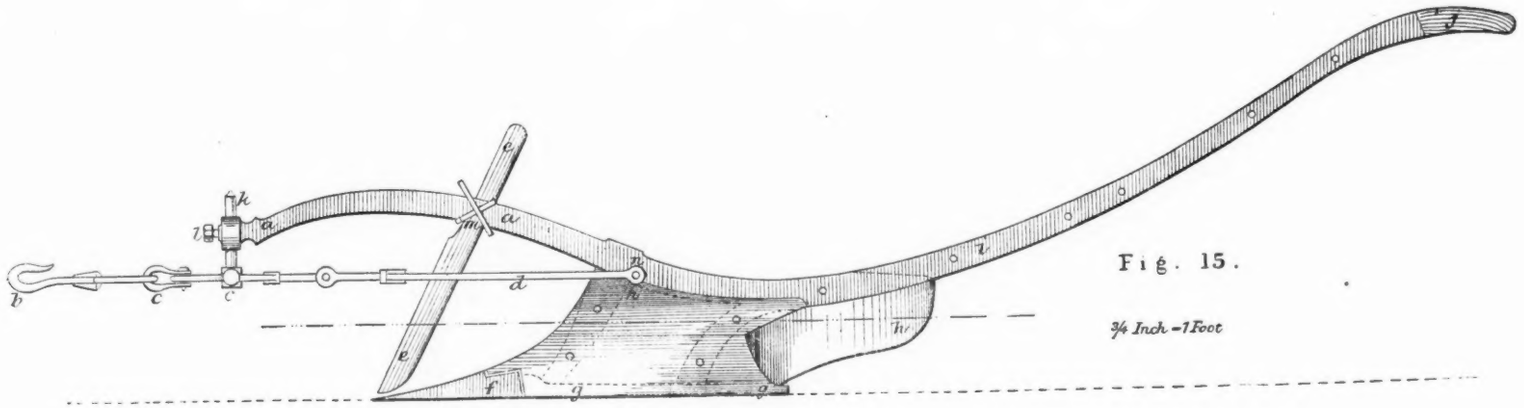


Fig. 15.

¾ Inch = 1 Foot

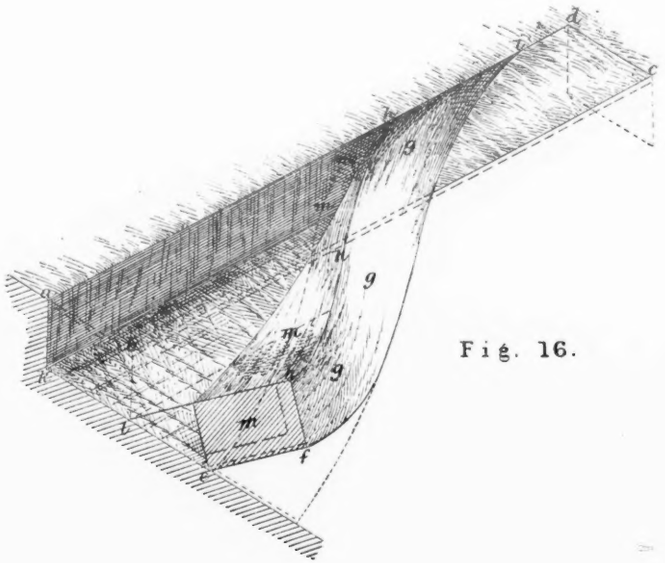
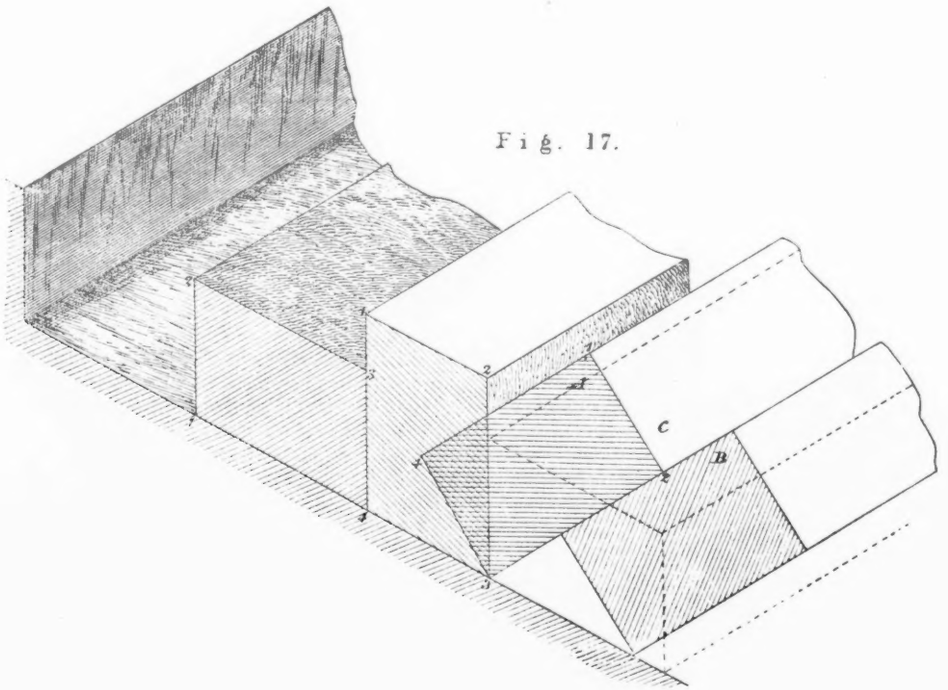


Fig. 16.

Fig. 17.



formed of wood. Veneers of wood were nailed on this mouldboard where it was thought the mouldboard was too lean, and the wood was reduced where the mouldboard was thought too full. The grieve, mechanic, and ploughmen were then consulted as to their idea of the form of mouldboard; and on their all agreeing, the plough was used with the wooden mouldboard. When the form of the wooden mouldboard was approved of on trial, a sheet of lead was laid on it and beaten into its shape. A casting of iron was then made from the leaden mould, and the iron mouldboard was tried in the plough. Alterations to effect the purpose in view under the guidance of the above parties were carried out, until, by repeated trials in this fashion, at least twenty in number, a mouldboard that could lay a furrow slice according to the model was at last attained. . . . . The model furrow slice was obtained by the experiment of digging a furrow with the spade, and laying a furrow slice in such a position as was wished to be done with the mouldboard of the plough. The wall of the furrow was cut perpendicular, with the floor made flat. A form of mouldboard that fitted the space prepared by the spade was accordingly made of wood, and its practical effect was immediately tested as above described."—*Deep Land Culture*, p. 33.

Having made these preliminary remarks, we are now prepared to consider the operation of the mouldboard and its constructive features.

A very fair idea of the effect produced by the mouldboard on a rectangular slice of soil separated by the coulter and share may be obtained thus:—Take a flat belt, or piece of cardboard, which we may suppose to be represented by the rectangle *a b c d*, fig. 16, lay it on the table, and while keeping one end, as *d c*, firm and flat, turn the other, *a b*, completely round, so that the edge, as *b c*, which was duly on the right-hand will be placed on the left, and what was the upper surface, as *a b c d*, will be the lower when laid flat on the table, or as *e f* when at an angle. The two ends of the belt will thus lie flat on the table, while the space between them will be twisted or screw-like, as at *g g g*; on turning over the one end, if the reader will carefully note its progress, he will derive a fair notion of the manner in which a slice of soil is turned over. Fig. 16 may also illustrate the operation of turning over the furrow slice; *a b* shows the breadth of the slice cut by the coulter entering near the point *i*, the curved form given to the mouldboard as the line *h h h*, turns over and deposits the slice in the position as at *e f h i*. The side, as *h f*, corresponding to *a k*, originally lying adjacent to the soil cut by the coulter, now forms the top side of the slice, as *h f*, while that which formed the bottom of the slice as cut off by the share, as *j h*, corresponding to *k l*, forms now the flat or upper side, as *i j*, while that which formed originally the upper surface, as *a b*, is laid in contact with the side of the furrow slice formerly laid over, as *e f*. It will thus be seen how completely all grass weeds growing on the surface, as at *a d*, will be buried by this operation and turned under, as at *e f*. To return to our illustration. The part *d c* represents the belt lying flat on the table, while the other end and side, as *e f*, being twisted round the dotted line *m m*, shows the belt; but to illustrate the turning over of the furrow slice, we have given a section of it, as *e f h j*. By looking through the opposite side of the page on which the diagram is printed, the reader will see in the reversed figure the second half of the belt, with its other extremity flat, and the full twist which would be given if the slice of soil could be completely turned over like the belt. The line *k l c* represents the surface line of soil, and all the furrow slices are turned over at an angle of 45°, as *e f h j*. This angle of inclination exposes the greatest possible amount of surface to the action of the atmosphere, and forms the best lines of furrows for depositing the seeds, presenting a series of "crests" in a favourable position for the action of the harrows. From this will be seen that the principal feature of the plough is its complete inversion of the soil in which it acts. Let us further investigate the matter. The cutting of the slice of a determinate breadth and thickness is performed, as we have seen, by the coulter and the sock or share. The share only partially cuts the horizontal part of the slice, the remainder being forcibly torn or wrested from the soil as the plough is passed through; while the slice so cut is transmitted and turned—as noticed above—over at a certain angle through the medium of the mouldboard. The slice during this transmission assumes a variety of positions, until it is finally deposited in such a way that the slice forming the upper surface of the soil is completely covered, lying against the slice previously deposited at an angle of 45°, while the side which formed the bottom is now fully exposed to the atmosphere, the same being the case with the side which lies against the unbroken land. The diagram in fig. 17 will illustrate three of the positions of the furrow slice; the first rectangle represents it when just cut, 1, 2, being the level side, cut by the coulter; 1, 4, the bottom, cut by the share. The second rectangle illustrates the vertical position of the slice where the side 1, 2, assumes the uppermost position, and the side 2, 3, that towards the right hand. The third rectangle illustrates the final position of the slice, in which the side 2, 3, formed by the top, assumes the position of the lowest surface, the bottom 1, 4, of the first rectangle now taking the uppermost or top position. The result of these movements is that the sides 1, 4, and bottom 1, 2, are partly exposed to the ameliorating influences of the weather, while the grass, stubble, &c., of the original upper surface 2, 3, are completely buried. A succession of slices when laid over assume the section as in fig. 17, giving a series of angular side furrows, or depressions, as *c*, formed between the crests, as *a b*, of the contiguous furrow slices. If the seed is sown broadcast or by hand, it naturally slides down, and is deposited in the bottom of the furrow or depression *c*; and when the crests are laid or levelled by the succeeding operation of the harrows, the seed is covered, and comes up in lines corresponding to the bottom of the depression *c*. What we have given on the mouldboard may be considered merely elementary—we have yet further somewhat to say about its operation and construction.

SCAMMONY from Turkey.—P. L. Simmonds. (*Pharm. Journ.* 3rd series, ii. 1006.) Scammony is the produce of many species of convolvulus, which require no culture, growing spontaneously on the mountains and slopes of hills in nearly all the districts of Asia Minor. They prefer a dry and stony soil, springing among the brambles and thickets, up which they twine. By the commencement of April the young shoots appear, and in May and June the plants are in their full vigour. July is the favourable time for collecting the juice, which is obtained from the roots, the stems being rejected as useless and inert.

In the month of July the natives, furnished with spades, knives, mussel-shells, and other receptacles, proceed to the mountains, or localities favourable for their search. Arrived at a suitable locality, they commence with the spade to free the roots of all substances which surround them, brushwood, earth, stones, etc., to a depth of about three or four inches. When this is done, they cut the large roots at their junction with the stem of the plant, and hollow it out so that the milky juice ascends and concretes in this receptacle, and is easily collected into the shells.

In the smaller roots and in other places incisions are made, to allow the sap to exude and drop into the mussel-shell, where it coagulates. Formerly it used to be dried and retained in these shells, and was called scammony "*de première goutte*;" and this kind is even now occasionally met with in commerce, but it has fallen into disuse, and the shells are only used as first recipients of the juice.

What is known as scammony of the second drop is obtained by expression, which is carried on in the following manner:—The entire roots are taken up, cut into pieces and pounded, so as to obtain the juice easily. This, when solidified, shaped into lumps, and divided into irregular pieces, constitutes the principal part of the scammony of commerce.

The author gives particulars of the scammony collected from different districts, and statistics of the amount produced.

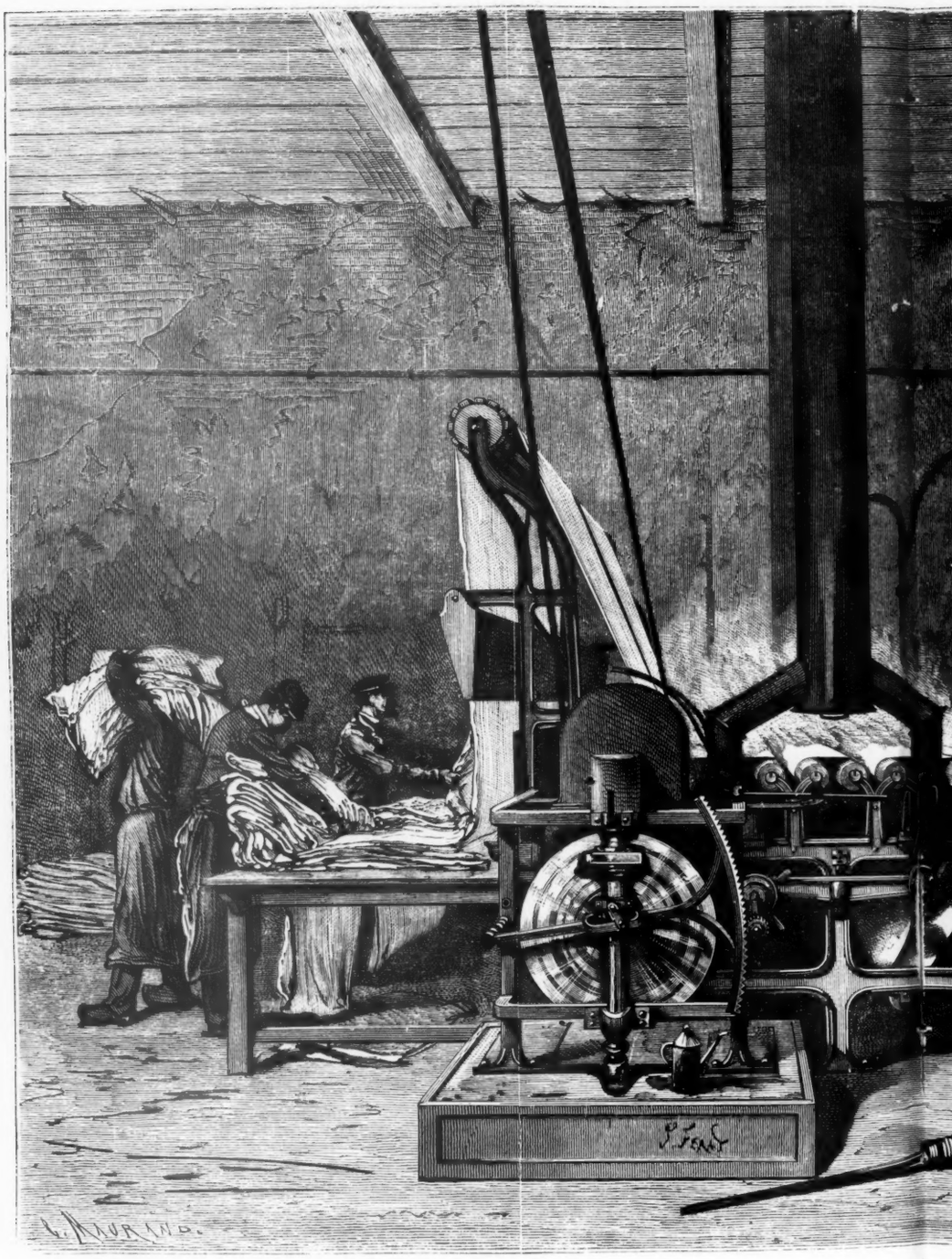
DYE WORKS OF MESSRS. BOUTAREL AND CO., CLICHY-LA-GARENNE.

DYES AND PREPARATIONS ON WOOLLEN STUFFS OR MIXTURES OF WOOL AND SILK:—MERINOS, DOUBLE MERINOS, CLOTHS, SCOTCH CASHMERES, MUSLINS, SATINS, POPLINS, VELVETS, REPS, BOMBAZINES, FLANNELS, SHAWLS, &C.

(*From "Les Grandes Usines,"* BY M. TURGAN.)

THE dye works of MM. Boutarel and Co. at Clichy-la-Garenne, in the outskirts of Paris, are the most important of their kind in the world, both in respect of the quantity and the superiority of their productions. The house was founded by Peter Gouin in 1800, in the isle of Saint Louis, at Paris, for dyeing of all shades hanks or skeins of wool, silk, or cotton. In 1822 Peter Gouin took for son-in-law and partner François Boutarel, who re-organized the labour and the material of the establishment. To the dyeing of hanks he added the scouring, dyeing, and preparation of all kinds of unbleached woollen cloths, and in 1828 M. Boutarel remained the sole chief of the establishment. From 1828 to 1844 the works increased in importance and in quality of production. In 1844, M. Boutarel exhibited for the first time, won the gold medal, and was nominated officer of the Legion of Honour.

In 1845 the works were transferred to Clichy-la-Garenne; and from 1850 to 1860 they were managed by Aimé Boutarel, who



THE SINGEING M

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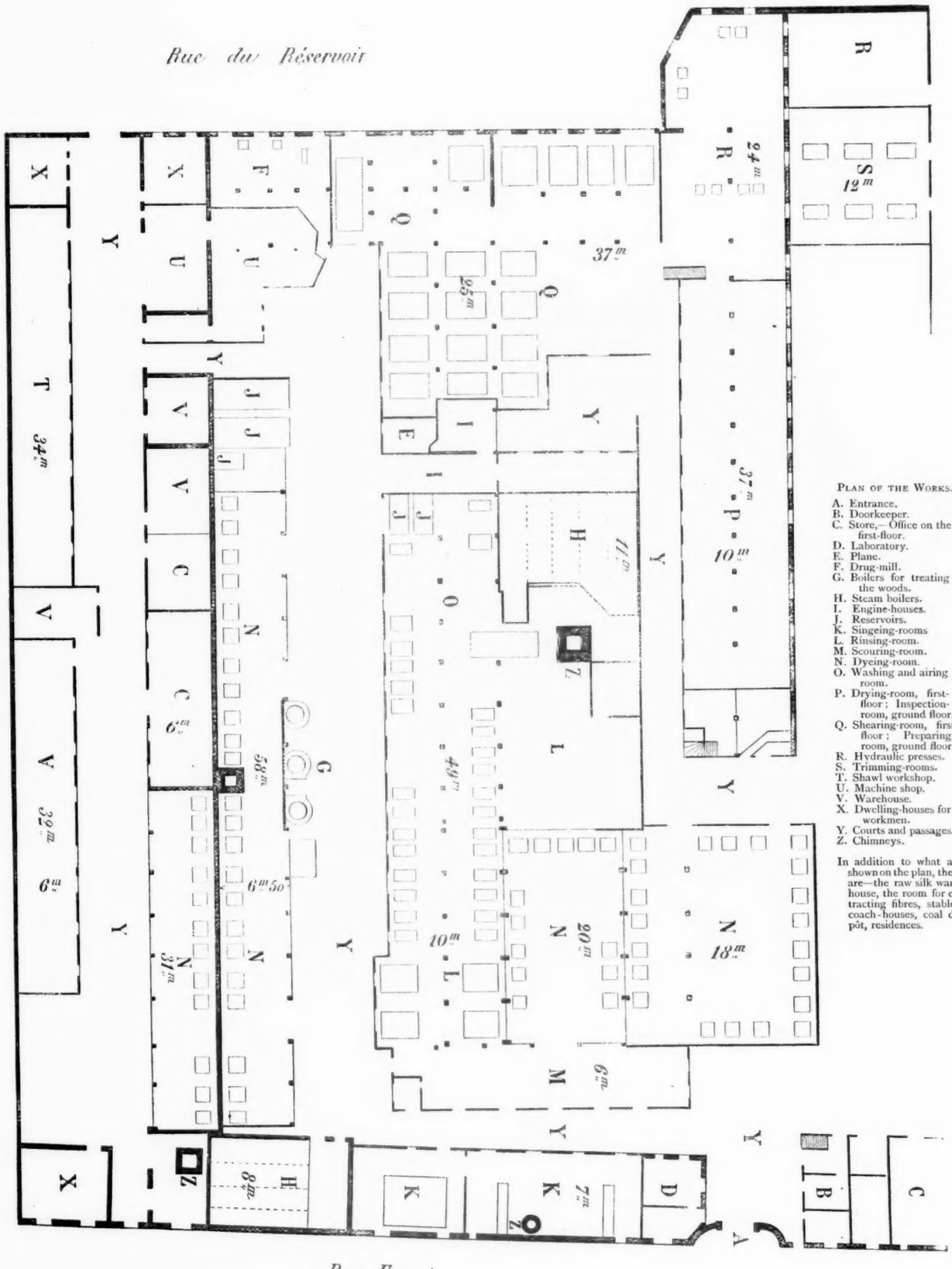

Rue du Réservoir
Rue Fournier
PLAN OF THE WORKS.
A. Entrance.
B. Doorkeeper.
C. Store,—Office on the first-floor.
D. Laboratory.
E. Plane.
F. Drug-mill.
G. Boilers for treating the woods.
H. Steam boilers.
I. Engine-houses.
J. Reservoirs.
K. Singeing-rooms
L. Rinsing-room.
M. Scouring-room.
N. Dyeing-room.
O. Washing and airing room.
P. Drying-room, first-floor; Inspection-room, ground floor.
Q. Shearing-room, first floor; Preparing-room, ground floor.
R. Hydraulic presses.
S. Trimming-rooms.
T. Shawl workshop.
U. Machine shop.
V. Warehouse.
X. Dwelling-houses for workmen.
Y. Courts and passages.
Z. Chimneys.
In addition to what are shown on the plan, there are—the raw silk warehouse, the room for extracting fibres, stables, coach-houses, coal depôt, residences.

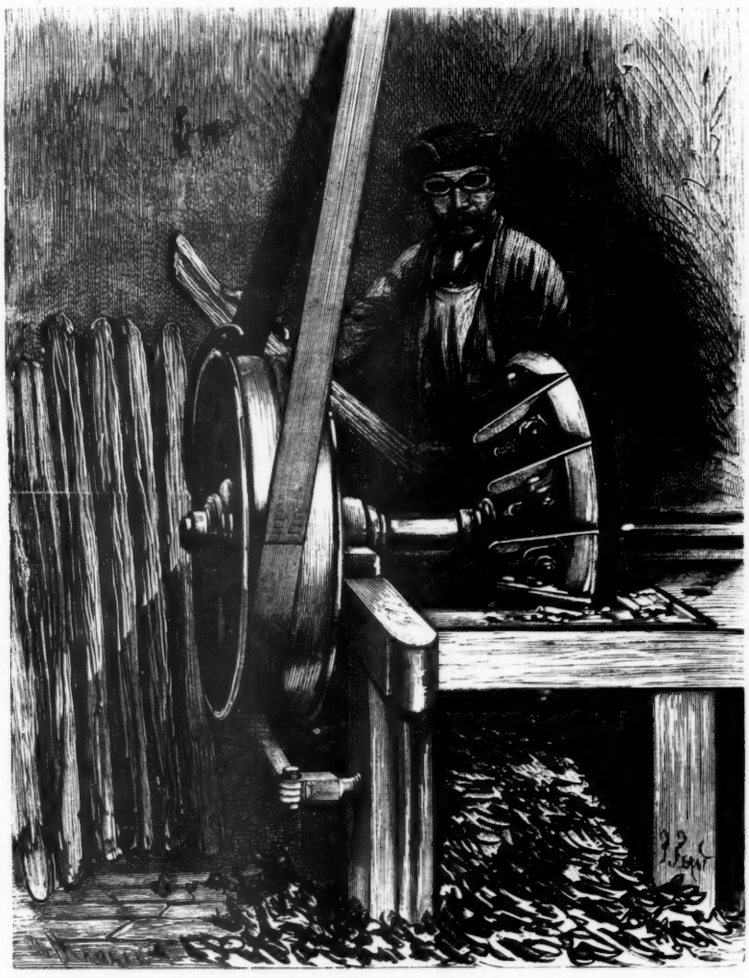
was chosen a member of the international jury at the Exhibitions of 1862 and 1867. Desirous, above everything else, to turn out his work at moderate charges, and to improve the quality of the work, he put into practice the great principle of political economy, namely:—in reducing the price of an article useful for supplying our wants, the number of consumers is increased, not only in the direct proportion of the reduction, but in a ratio ten times greater. He was enabled also to increase progressively the salaries of the employés.

The production, which amounted in 1852 to three and a-half millions of metres annually, amounted to 4,300,000 metres in 1855, and to 9,000,000 in 1868.

In 1860 Aimé Boutarel took into partnership Louis Chappat, and in 1862 they won the large medal at the Exhibition of that year.

In 1867, Aimé Boutarel, being a member of the international jury, his establishment was excluded from competing; but the jury awarded a gold medal to the foreman, Louis Noizoette, for superior execution.

The works at Clichy cover about three acres and three-quarters of ground, and the machinery is driven by steam-engines of a total power of eighty horses. The heating boilers are equal to two hundred and eighty horse power. Besides this, the works are furnished with machines for performing the various processes—forges, lathes, a coppersmith's shop, and carpenters' shops. Considerable capital has been sunk in these



SHAVING MACHINE (*varlope*).

machines and workshops, but the greater part has already been passed to profit and loss.

The production of the works ever since they were established has constantly increased. Thus, taking more recent years, the production in

1864	amounted to	114,000 pieces
1865	„	119,000 „
1866	„	121,000 „

averaging nine and three-quarter millions of yards per annum.

There are permanently employed at Clichy five hundred men and women. They have a benefit club, from which assistance is obtained in case of accident or sickness.

Store for Unwashed Goods.

Before entering the works, it is well to inspect a large building of brick and iron, in which are stored the unwashed stuffs which come from Rheims, Roubaix, Saint Quentin, and Cateau. These stuffs, the raw material of the dyer, are delivered to him yellow and soiled from the loom, and it is his duty to dye them of the most delicate shades, of uniform colour, lively, bright, warm, and smooth, and to deliver them to their owners suitably finished and neatly rolled upon small boards.

The most minute precautions are taken to avoid the slightest confusion in the various operations. The unwashed piece, after having been measured, receives a number, which is marked on both ends of the piece. The number is entered in books belonging to each department, against which are marked the several operations to which the piece is to be submitted. From the store the piece passes successively to the boiling shop, the cleansing shop, the dyeing shop, the washing shop, the drying room, the inspection room, the picking room, the shearing room, and the press room, where the piece is finished in the hydrostatic

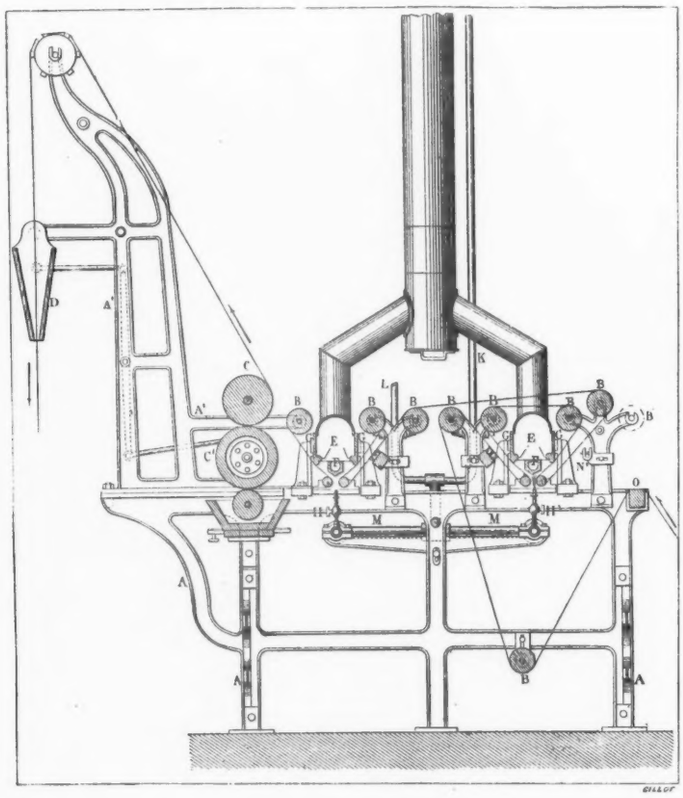
press, whence it is finally lodged in the delivery department to be despatched.

The industry of dyeing, when it comprises the entire treatment of stuffs, is one of those which demands the co-operation of the greatest number of intelligent workers. The stuffs pass through so many hands and so many machines before being ready for delivery, that it is difficult to comprehend how they can be submitted to so many operations for a few halfpence per yard.

Store for Dye Stuffs.

To the right of the principal entrance of the works is the store for the drugs and various other materials used for the dyeing of the goods. In several apartments, well fitted up, all the dye stuffs and chemical products are classified and arranged. A special clerk is employed to register the incoming and the outgoing of every article; and at the end of every month an inventory is taken, which shows the exact expense for each of the dye workshops, and of all the other shops in the works. At the side of the store there is a fine laboratory fitted up with gas, steam, water, and everything else necessary for the operation. There all the products are tested, and every new discovery is applied and tried by young and well-instructed chemists.

The principal chemical agents employed at Clichy, and the quantities consumed annually, are as follows :—



SINGEING MACHINE.

	Tons.
Muriatic acid	90
Sulphuric acid	56
Nitric acid	18
Picric acid	1½
Alcohol	25
Carbonate of soda	130
Soap	30
Tartar and crystallized tartar	35
Alum and sulphate of alumina	60
Oxymuriate and salt of tin	19
Red cyanide	3
Bichromate of potash	12
Sulphate of copper	32
Sulphate of iron	6
Sulphate of soda	52
The principal colouring matters are :—	
Carmine and a compound of indigo	22
Cochineal	6½
Turmeric	42
Sorrel	120
Logwood, Yellow wood, Red wood, Fustic	280

Colours extracted from coal-oil :—Yellow, red, violet, blue, green, &c.

Of coal, 6,000 tons are consumed annually, say 20 tons per working day.

Treatment of the Raw Materials.—Formerly, dyers gave out their raw materials to be prepared, but they have found by experience that, to be perfectly sure of their colouring matters, it was better to treat the dye stuffs themselves.

Thus, at Clichy, the woods are cut up into shavings by a shaving machine (*varlope*), and dried, to be used in liquid extracts. Three large boilers are employed for this service. The batches of logwood are delivered into a large sheet-iron reservoir; those of red wood are sent into large wooden tubs; those of the yellow wood, into small wooden reservoirs. From these various receptacles the extracts are conveyed in pipes underground direct to the various dyeing rooms. Thus all the rooms are supplied with dye extracts without the aid of any hand labour.

There are, in addition, mills for grinding the cochineal and pulverising the turmeric, as well as machines for crushing the crystals of tartar, alum, &c.

Singeing Machine, by Tulpin of Rouen.

A, the frame of the machine; A′, frame carrying the drawing-rollers and folder; B, B, &c., guiding rollers for the cloth; C′ C′, the drawing rollers, of which C′ makes sixty revolutions per minute; D, mechanical folder; E E, funnels over the lines of

flame, connected by elbows with chimneys ; F F, flame dividers in the middle of each funnel ; G G, slides to prevent all communication between the external air and the funnel; H H′, supports for the horizontal singeing tubes, which form two lines of flame reaching nearly across the machine. The jets are disposed zigzag ; I, large fan to remove the products of combustion ; J, small fan to drive air into the gas tubes, moved by the large fan by means of grooved pulleys ; K, tube into which the small ventilator sends the air ; L, gas tube ; M M, tubes to conduct the mixture of gas and air ; N N′, flat brushes to remove the down from the cloths at the moment of singeing—they may be replaced by circular brushes.

Singeing.

The first operation to which the stuffs are submitted is singeing, the purpose of which is to remove the small threads and filaments which are set free during the twisting of the cloth. The quick burning or singeing of these filaments is effected by the machine designed by M. Tulpin, of Rouen, of which the following excellent account is given by M. Laboulaye : "It is well known that many stuffs, particularly cotton cloths, have their surfaces, after having been washed and bleached, covered with a down which is not agreeable to the eye, and would, if permitted to remain, detract from the appearance of the cloth. This down is

THE CLEANSING MACHINE.

removed by burning or singeing it off, which is effected by passing the cloth with sufficient velocity over a highly-heated metallic surface, or through a flame. The second plan, the application of which was facilitated by the introduction of gas, was gradually abandoned in later years, because when the cloth passed above the point of the flame, the singeing action extended to the filaments within the body of the cloth, which became more transparent and thinner, and lost value in the market. M. Tulpin happily obviates this objection by presenting not the point of the flame, but its side to the cloth, which nearly touches the flame. This machine is arranged so as to repeat the singeing action at will on one side of the cloth ; the steadiness of the flame is insured by the action of a fan, which withdraws the products of combustion, and of a smaller fan which delivers air for mixing with the gas in the proportions proper for burning it with a blue flame, so as to yield heat rather than light, and to prevent smoke. It is adopted everywhere, and it satisfies every condition."

The chemical composition of wool is as follows :—

Carbon	50·6
Hydrogen	7·0
Nitrogen	17·7
Oxygen and sulphur . .	24·6
(say) . .	100·0

Three varieties of fabrics are derived from wool : Pressed fabrics (*tissus foulés et drapés*), consisting of short carded staple ; light and unpressed fabrics (*tissus légers et ras non foulés*), longstaple, combed ; and mixed fabrics (*tissus mixtes*) medium staple, carded and combed.

It is with the second of these fabrics principally that we shall deal in this article. By means of the new machinery, the conversion of the raw material into threads, and ultimately into fabrics of every kind, has come to be regarded as an elementary process ; and with the abolition of the duty on imported raw

material, the cost of production has been greatly reduced. Products not long since considered as articles of luxury have become indispensably necessary, and our workmen, dressed in wool winter and summer, have been rendered much less susceptible to disease.

It is not, however, sufficient to invent machinery for producing cloths of every variety. They must be dyed or printed in various shades, as pure as possible, to please the eye of the purchaser; for it must be added that the great consumption of woven fabrics is due to the taste and the perfection of the design and its execution.

Before the fabric is submitted to the process of dyeing it is subjected to several preliminary operations, which are known under the general designation of cleansing (*dégorgeage*).

The first operation of cleansing is to discharge the size with which the warp is charged in the first place. Sizing, or binding with gelatine, is necessary for the purpose of weaving the cloth, and fulfils two objects: it strengthens the threads to enable them to withstand the stress of the loom, and it prevents the threads from adhering to each other. When the piece is woven, it is unsized by being passed through a bath of hot water, which dissolves the size, the temperature of the bath being regulated according to the nature of the web.

Then follow the operations of washing, rinsing, and rolling.

The washing is conducted by, in the first place, passing the piece through a bath of soap and carbonate of soda at 86° Fahrenheit, in which the fatty and insoluble matters are saponified and rendered soluble; in the next place, the piece is passed through a bath of carbonate of soda at from 95° to 105° Fahrenheit, by which the soap and all the greasy matters are dissolved and extracted from the piece.

The piece is then rinsed with plenty of water, and finally treated with a moist preparation to remove all folds before being dyed.

Dyeing.

The art of dyeing, the object of which is to effect a uniform combination of colouring matter with the substance of cloth, is as old as the world; and though founded on the laws of chemistry, it existed before that science was known. Like many other processes in the useful arts, it was conducted by routine and based on simply empirical practice. Tyre and Sidon were renowned for their dyes—Tyre, above all, for her purples, the colouring matter of which was extracted from a mollusc of the Mediterranean. Strabo, a hundred years before Christ, writes of India as a country which furnished many beautiful colours; Egyptian mummies have been found wrapped in blue bandages, and the red of Adrianople, extracted from madder, appears to be very ancient. Homer and Hesiod allude to the use of colours by the ancients. To wear a coloured robe was an attribute of kings and gods. Red, especially purple-red, was reserved by Moses for the ornamentation of the Tabernacle and the costume of the High Priest; it was also the colour dedicated to Jupiter. The gods and goddesses had their own special colours. Neptune was blueish-green; Apollo was deep blue or violet; Cybeline, bright green; Juno, sky-blue; Ceres, yellow; Minerva, the colour of fire; Venus, golden yellow. It does not follow, however, that though the ancients knew something of dyeing, the art was carried to any great degree of excellence by them, or that it was very widely known. Coloured stuffs were costly, and the sources from which the colours were drawn were restricted in number—as the molluscs already mentioned, the alkanet, the blood of birds, sea-weeds, furze, violets, the lucern, the bark of walnut tree, madder, gall-nuts, woad, and sulphates of iron and copper. Later, the seeds of a species of wild vine were used, and the gamut of colours was so augmented that Ovid compared them to the flowers of spring. In the games of the circus the chariot drivers were divided into four sections, distinguished by different colours. There were the *factio-alba*, or *albata*, the whites; the russata, the reds; the *veneta*, the blues; and the *persica*, the greens. Under Domitian, two other colours were added: the *aurata*, the gilded; the *purpurea*, the purples.

It is probable that many trials, more or less successful, were made in those times; but the art of writing was doubtless foreign to the habits of practitioners in dyeing. Their discoveries, like many others made before printing was invented, have been absolutely lost to mankind, which has thus been forced many times to recommence the rolling of the stone of Sisyphus.

In India the dyeing of cotton, wool, and silk has been brought by the natives to a high state of perfection, and the products are highly appreciated in Europe at this day.

During the first twelve centuries of the Christian era the knowledge of dyeing appears to have disappeared, but was revived on the return of the Crusaders from Syria, who brought from the East, with other arts, the art of colouring stuffs. The discovery of the New World brought Brazil wood to our knowledge, also logwood, annotto, and cochineal. Indigo, brought to Europe from the East Indies by the Dutch, was not well received either by the Government or by the trade.

It was under Francis I. that Gilles Gobelin founded, at Paris, the first establishment for dyeing wools; but it was only in 1669 that Colbert caused to be published the first documents on that industry.

We have now got past the era of empiricism. The art of dyeing has become an exact science more easy of application, due chiefly to the marvellous colours extracted from coal tar. This progress we owe to chemistry. Within the last twenty years dye-works have been reconstituted and matured. Manual labour has been replaced by machinery.

Since the treaty of 1860, the dyeing industry has made great advances. The rapid progress made may be comprehended when it is recollected that, in 1859, certain chemical products were protected to an extent far beyond their simple values. For example:—

Sulphuric acid, price per 100 kilogrammes	16 *frs.*,	duty	41 *frs.*
Nitric acid	„	„	48 „	„	90 „
Muriatic acid	„	„	9 „	„	62 „

The following comparative table of the cost of various chemicals illustrates the effects of the Treaty of Commerce in lowering their prices:—

Comparative Table of the Prices of some Chemical Products in 1859 and 1867.

	Per 100 kilogrammes. In 1859	In 1867.
Muriatic acid	11 *francs*	6 *francs.*
Sulphuric acid, 66°	17 „	11 „
Nitric acid	47 „	38 „
Crystallised soda	26 „	17 „
Salt of soda	52 „	38 „
Sulphate of soda	18 „	12 „
Bichromate of potash	237·5 „	135 „
Oxymuriate of tin	170 „	110 „
Prussiate of potash	390 „	290 „
Sulphate of copper	87 „	72 „

The affinity of colouring matters is greater for animal substances, as wool and silk, than for vegetable matters, as cotton and hemp. Wool takes the dye at a boiling heat, silk at a tepid heat, and cotton at a cold temperature. The mordant specially suited for wool is sulphate of alumina; for silk, alum; and for cotton, acetate of alumina.

The art of dyeing is to effect the union uniformly of colouring matters with woven goods or cloths.

Colours may be classed as simple, compound, light, or dark. The principal colouring matters (cochineal, madder, sulphate and carmine of indigo, logwood, Brazil wood, yellow wood, fustic, turmeric, &c.) if employed alone, have but little affinity for woollen cloths, and still less permanency. Means are therefore necessary for fixing the colours, and for giving them brightness, intensity, and durability; for this purpose certain salts are employed, mineral and organic, soluble in water, which have the property of fixing themselves energetically on textile fabrics, and to combine with colouring matters, forming with them insoluble compounds. The intermediary salts are technically called mordants.

[The process of fixing the colours on the cloths is known in France as *le mordançage des tissus*, for which designation there does not appear to be an English equivalent.]

Mordants are of two sorts, colourless and coloured. The colourless mordants are alum, sulphate of alumina, bisulphate of soda, bitartrate of potass, salts of tin, &c. Coloured mordants are sulphate of iron, sulphate of copper, bichromate of potass, &c.

Mordants are applied either in conjunction with colours or separately. In the first case, the goods are placed in a bath, consisting of a mixture of the mordant and the colouring matter. In the second case, the goods are passed, in the first place, through a bath consisting of the mordant simply, and then through the colour bath.

Acids are not suitable as mordants: they tend to decompose the colouring matters. Our principal mordants for woollen fabrics will always be alumina and oxide of tin, on account of their powerful affinity for the fabrics and for the colouring matters, and their small affinity for acids.

Two qualities are essential in the dyeing of woollen fabrics: fixity and uniformity. That the colour of a piece may be said to be well fixed, it is essential that after the operation of washing, either in a river, or by mechanical means, the colour should neither be changed nor removed. Uniformity of colour is arrived at not only by means of a well-chosen mordant, but, more than all, by means of special and continued airing. It is well known

that atmospheric oxygen with the presence of light is the chief agent of colouring. In the process of dyeing, in order to colour or to effect the union of the colouring matters with the fabrics uniformly, the oxygen of the air alone is necessary; without it, the goods are daubed.

For dyeing, large tubs are employed holding from 300 to 400 gallons of water, heated by steam passed through a copper worm. In this water, slightly acidulated, heated to the boiling-point, the colouring matter is dissolved, and the dyeing bath is ready. For the proper aëration of the fabric, it is passed several times over a reel suspended about three feet above the bath, after having been plunged into the bath.

There is another point in dyeing—the sampling. For example, the pieces are usually dyed by twos or by fours, the application of the mordant occupying from two to three hours, and that of the colouring matter one hour. Given 100 pieces, or 8,000 metres (8,880 yards) of cloth to be dyed to the same sample, the foreman must be skilful and experienced in order to dye all the pieces to one identical pattern.

At Clichy, all the colours are made on the premises, and each colour has its special workshop, with its own foreman; and this may go to explain the perfection at which the production of the various shades has arrived. Each workshop is named after its colour:

THE COCHINEAL MILL.

1. Workshop for fine colours.
2. do. „ blacks.
3. do. „ greens.
4. do. „ bright colours.
5. do. „ dark colours.
6. do. „ French blue.
7. do. „ colours extracted from coal-oil.

WORKSHOP FOR FINE COLOURS.

Colours.	Mordants.	Colouring Matters.
Flame colour	Crystals of tartar	Cochineal
Crimson	Oxalic acid	Ammoniacal cochineal
Yellow	Composition of tin	Fustic wood
Orange		Black oak

Cochineal.—Originally from Mexico, discovered in 1518, cochineal was introduced into France in the form of red dried grains, in sacks of one hundred and fifty-four pounds each. It was one of the sources of wealth acquired by Spain through the discovery of America, and for a long time she retained the monopoly of that dye. It was imported into the Canary Islands in 1827, but it was not cultivated there until the year 1833.

For many centuries it was thought that the cochineal was a vegetable substance. It is, in fact, an insect; but its feet are so small that it is hardly capable of motion, and it lives, almost immoveably, on the *cactus nopal*. The harvest is gathered into straw-baskets; the insects are stifled in stoves, and are then dried in the sun. There are three principal varieties of cochineal imported into France:—

From Honduras	Cochineal,	black or *zacatille.*
„ do.	do.	grey
„ Mexico	do.	grey and *zacatille.*
„ Canary Islands,	do.	black and silvery.

The colouring matter is known as carmine, and supplies the finest red colour.

The average quantities imported for five years were as follows:—

London	22,000 sacks.
Liverpool	10,000 do.
Marseilles	5,000 do.
Havre and Bordeaux . .	1,000 do.

Say 2,666 tons, of which the average price is 4·4*d.* per pound, making a total value of upwards of a million sterling.

BOILING DYE-W

E-WOODS.

Ammoniacal Cochineal.—If two pounds of powdered cochineal be macerated with four pounds of sal-ammoniac for fifteen days, and the ammoniac be then evaporated, two pounds of ammoniacal cochineal in the form of paste is obtained. This composition dissolved in boiling water yields the magnificent colour crimson, which is now replaced by magenta, extracted from coal-oil.

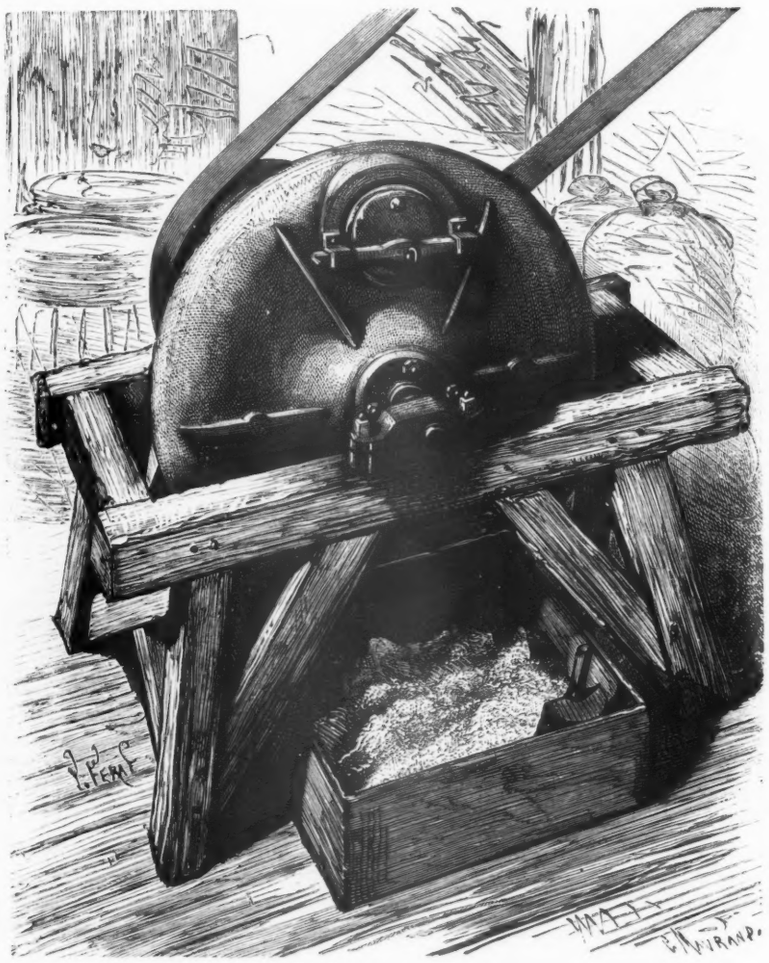
Madder.—This is one of our rich colouring matters, derived from a lively plant cultivated in Europe, Asia, and Africa. The root dried and pulverized furnishes a red colouring matter, as rich as the blue matter extracted from the indigo plant.

Kermes.—A parasitic insect that lives on the green oak. The colour is violet-red ; with alum and tartar, it turns to a reddish brown.

Fustic.—This shrub grows in Albania ; its wood contains a yellow colouring matter, which is used principally to mix with and qualify other colours.

Black Oak.—The pulverized bark of the *quercus tinctoria*, or black oak of North America. It yields a rich yellow colour. According to Chevreul, this colour contains a good proportion of tannin, a red colouring principle, a brown principle, and a yellow matter soluble in water.

The *fine colours* were known in the east by reason of their superior brightness ; they were much sought after by sovereigns and



TARTAR AND ALUM GRINDING MACHINE.

chiefs. At Rome, the Imperial purple was so called, no doubt, from the fact that it was not permitted to be worn by any other than the members of the Imperial family.

The ancients knew how to dye in scarlet, in purple, and in red. To manufacture these colours they employed kermes and madder. The discovery of cochineal only dates from the commencement of the sixteenth century.

The fixing on wool of the red colour of the cochineal by the aid of a composition of tin, dates from the year 1563. It was one of the great discoveries in the art of dyeing. It was known at that time that the salt of tin was that which had the strongest affinity for woollen fabrics, and that its white base gave to the combinations which it formed with the colouring matter in the fabric, brightness, clearness, and permanence.

In France we are indebted for the secret of dyeing in scarlet to Gilles Gobelin, who, in the sixteenth century, founded his establishment for dyeing wools on the banks of the Rièvre river. Formerly, everyone had his own prescription for the tin composition, and each receipt produced a different shade. In the sixteenth century they employed aquafortis (a kind of nitro-muriatic acid), now they use simply nitric acid at 36°, diluted in water in which pure tin is slowly dissolved, to which is added a small quantity of chloride of sodium (common salt), forming an excellent tin composition.

Application.—Six pieces are boiled for two hours in a large tub with bitartrate of potash and the tin composition. The next day the pieces are washed in cold water, to remove the uncombined mordant, and then plunged into the colour bath at the boiling point, in which the cochineal, previously completely pulverized, has been dissolved. The pieces are thus dyed crimson-

red; and if a warmer tint is desired, a sack of fustic wood is added to the bath.

Yellow, Maize, Golden, Orange.—These colours are directly obtained in the bath containing mordants and colouring matter. The mordants are tin composition and bitartrate of potash; the colouring matters are finely pounded cochineal and fustic wood in a sack, in varying proportions according to the desired shade.

The colouring matter of fustic wood, it may be explained, is not extracted by any previous process of decoction. The wood is cut up into chips, and enclosed in linen sacks, which are placed in the bath, and allowed to remain there for a greater or less length of time, according to the depth of shade required.

(*To be continued.*)

ON THE UTILIZATION OF THE RESIDUE OBTAINED BY BURNING PYRITES IN THE MANUFACTURE OF OIL OF VITRIOL.

By C. R. A. WRIGHT, D.Sc., LECTURER ON CHEMISTRY IN ST. MARY'S HOSPITAL MEDICAL SCHOOL.

THE credit of suggesting the use of pyrites (iron disulphide) as a source of sulphur in the manufacture of sulphuric acid is usually attributed to Dr. Manson; but it is stated that Hill, of Deptford, employed this material as far back as 1818. Processes for extracting sulphur itself and its compounds from pyrites, however, were in use at far earlier dates than this. Thus, Matthew Sanderson took out a patent in 1778 for a "New process for the extracting a mineral sulphur from pyrites, copper and lead ores, separating its acid (*sulphurous* acid?), and rendering it useful for every medicinal purpose;" and in 1780 the same inventor patented a "New process for extracting from lead glitter, &c., alum, sulphur, &c., refining and separating their metallic contents by a blast-furnace, &c." The production of the various "vitriols" (green vitriol, or ferrous sulphate; blue vitriol, or copper sulphate; white vitriol, or zinc sulphate, &c., &c.) by the natural or artificial oxidation of the sulphides of various metals, again, was known at a much earlier period still; and hence the production of (Nordhausen) sulphuric acid indirectly from pyrites, by calcining and distilling the green vitriol thus obtained from it, is a manufacturing operation of less recent date than usually supposed.

In 1838 Gossage proposed to obtain sulphuric acid from pyrites by burning off part of the sulphur, so as to leave protosulphide of iron behind, and then treating the residue with hydrochloric acid, whereby the residual sulphur is expelled in the form of sulphuretted hydrogen, which is then burnt so as to produce sulphurous acid and water vapour; and in 1839 Dyar and Chisholm, and also Duclos, patented improvements in the methods of preparing sulphur from pyrites, the latter inventor proposing to make sulphuric acid by roasting the protosulphide of iron formed by heating the pyrites in airtight retorts (whereby sulphur is expelled and distils over), so as to convert it into anhydrous persulphate of iron (ferric sulphate), which is then to be used as calcined vitriol is still in the manufacture of Nordhausen sulphuric acid.

Since then, many improvements, too numerous to specify in detail, have been made by Spence, Farmer, Blair, Clapham, Gossage, and many others, in the processes for extracting sulphur and its compounds from pyrites, and the nature of the apparatus employed in so doing; the result of which is that at present only an inconsiderable part of the sulphuric acid manufactured in Great Britain is produced directly from sulphur, by far the greater amount being obtained from pyrites of one kind or other.

Although pure pyrites, when occurring in a crystallized condition, is a uniform substance consisting of

Iron	46·67
Sulphur	53·33
	100·00

yet the substances actually in use in the manufacture of oil of vitriol under the name of pyrites exhibit, in many cases, great divergence from this composition. These differences are, however, mainly due to the presence of other substances admixed with the pure pyrites or iron disulphide. Of course, the nature of the residue left on burning such substances varies greatly, being dependent on the kind and amount of the foreign substances mixed with the iron disulphide. When but small amounts of foreign matters are present, the chemical changes that ensue during the process of "burning" the pyrites may be represented thus: The iron disulphide, $Fe S_2$, splits up into sulphur and ferrous sulphide, in accordance with the equation—

$$Fe S_2 = S + Fe S,$$

so that one-half of the contained sulphur is eliminated in the free state. Ordinarily, the pyrites burners, or "kilns," are so constructed that this sulphur is burnt to sulphurous acid by the agency of the air passing through the kilns as fast as it is generated. Occasionally, however (usually by mismanagement), unburnt sulphur sublimes in such quantities as to form a thick deposit in the flues, sometimes almost blocking them up. By the continued action of the air on the residual ferrous sulphide, the majority of the sulphur contained in this compound is also eliminated as sulphurous acid, the iron taking up oxygen and becoming ferric oxide in accordance with the equation—

$$2 Fe S + 5 O = Fe_2 O_3 + SO_2.$$

Usually a small portion, however, becomes converted into ferric sulphate (excessively basic, being formed in presence of large excess of ferric oxide), thus:—

$$4 Fe S + 17 O = Fe_2 (SO_4)_3 + Fe_2 O_3 + SO_2.$$

For this reason, together with others hereafter discussed, it is practically impossible to remove *all* the sulphur from the iron disulphide; as the great majority is, however, expelled, the burnt residue left in the pyrites kilns may be stated roughly to consist of ferric oxide mixed with whatever non-volatile earthy matters and other impurities were contained in the original pyrites.

The composition, therefore, of the residue may be fairly inferred from that of the original pyrites by substituting for the sulphur, and the iron associated with it in the form of iron disulphide, the equivalent quantity of ferric oxide.

Frequently, however, the pyrites used contains, not only non-volatile earthy matters, but also more or less volatile and alterable metallic or other constituents, *e.g.*, arsenic, zinc, copper, &c., &c. The presence of these in the original pyrites will, of course, modify the composition of the resulting burnt "sulphur ore," these constituents being in some cases partially volatilized, in others oxidized, and otherwise altered.

The following tables give a fair idea of the general composition of many of the varieties of pyrites in daily use:—

Sources	Huelva and Tharsis Ores: averages.				Tuscany.
Analysts	C. R. A. Wright.	R. C. Clapham.		Wedding and Ulrich.	R. C. Clapham.
Sulphur	49·07	45·21	47·50	43·52	48·90	48·4
Iron	44·28	43·50	41·92	40·20	43·55	44·5
Copper	2·75	2·21	4·21	3·12	3·10	—
Arsenic	0·38	0·41	0·33	1·10	0·47	—
Zinc	—	—	0·22	0·32	0·35	—
Lead	—	0·22	1·52	2·11	0·93	—
Quartz, sand, &c.	2·34	7·10	3·40	8·00	} 2·70	3·6
Alumina, lime, moisture, and undetermined matters	1·18	1·35	0·90	1·63		3·5
	100·00	100·00	100·00	100·00	100·00	100·0

Sources	Belgium.			Cornwall.	
Analysts	R. C. Clapham.		Browell and Marreco.	R. C. Clapham.	
Sulphur	42·80	35·50	51·59	25·27	34·34
Iron	36·70	38·60	45·50	27·77	32·20
Copper	—	—	trace	4·60	0·80
Arsenic	0·20	0·31	trace	trace	0·91
Zinc	0·40	5·26	—	9·08	1·32
Lead	0·92	0·65	—	1·44	0·40
Quartz, sand, &c.	8·86	14·90	2·20	31·67	29·00
Alumina, lime, moisture, and undetermined matters	2·89	0·54	0·71	0·17	1·03
Oxide of iron	7·23	4·24	—	—	—
	100·00	100·00	100·00	100·00	100·00

Sources	Ireland.		Wicklow.		Piedmont.
Analysts	R. C. Clapham.		C. R. A. Wright. (average)	R. D. Thomson.	Browell and Marrico.
Sulphur	40·41	34·67	30·84	47·41	44·60
Iron	32·22	42·40	—	41·78	40·26
Copper	4·13	1·33	1·29	1·93	trace
Arsenic	—	0·18	—	2·11	trace
Lead	2·96	1·59	—	—	—
Zinc	—	—	—	2·00	—
Silica	17·67	20·00	—	3·93	14·30
Alumina, lime, moisture, and matters undetermined	2·61	—	—	0·84	0·84
	100·00	100·17	—	100·00	100·00

Sources	Pomerania.	Westphalia.	Sweden.	Italy.	Cleveland. Yorkshire.	Coalbrasses.
Analysts	Browell and Morrico.	Pattinson.	Browell and Marrico.	Pattinson.	Pattinson.	R. D. Thomson.
Sulphur	48·75	45·60	38·05	47·00	27·80	53·35
Iron	42·93	38·52	42·80	42·20	24·32	45·07
Copper	2·87	—	1·50	—	—	—
Arsenic	trace	trace	—	trace	—	—
Lead	—	0·64	—	trace	—	—
Zinc	—	6·00	—	trace	—	—
Silica	3·20	8·70	12·16	9·20	11·12	0·80
Thallium	—	trace	—	—	—	—
Cobalt	—	trace	—	—	—	—
Oxide of iron	—	—	—	—	11·92	—
Moisture, alumina, lime, and undetermined matters	2·25	0·54	5·49	1·60	24·84	0·08
Manganese	—	—	—	—	—	0·70
	100·00	100·00	100·00	100·00	100·00	100·00

Practically sulphur ores may be divided into two principal classes, viz., those which contain little or no earthy matters, and are made up essentially of sulphur and iron, with more or less copper; and those which contain large amounts of earthy substances; of these the Spanish and Irish pyrites may be regarded as representative types respectively. Ores which contain large amounts of copper or lead, or of more valuable metals, may be left out of account, inasmuch as the treatment to which they are subjected is ordinarily based on the desire to extract the more valuable metals rather than the sulphur, the latter constituent being in most cases disregarded and not utilized; such ores as these, therefore, rather belong to the subject of metallurgy than to that of vitriol making. As above stated, the main changes that ensue during the process of burning the pyrites are the volatilization of the majority of the sulphur and arsenic in combination with oxygen, and the conversion of the iron di-sulphide into peroxide in accordance with the equation—

$$2\,Fe\,S_2 + 7\,O = Fe_2\,O_3 + 2\,SO_2;$$

when copper is present, however, a certain proportion of sulphur is always retained in the form of a sulphide of copper, which usually accumulates in the centres of the lumps of burnt ore, forming a kind of kernel or nucleus. Even, however, when no copper is present, it is practically impossible to extract by combustion the whole of the sulphur originally present in union with iron. To oxidize completely the whole of the iron as indicated by the above equation would require a more prolonged roasting than can usually be allowed; moreover, as formerly stated, a certain portion of sulphur is frequently retained in the form of a persulphate of iron, or a sulphate of copper, or of some earthy metal contained in the "gangue" of the sulphur ore (as pointed out below, the production of sulphate of copper by this re-action has been proposed as a means of extracting metallic copper from pyrites containing it). The amount of sulphur thus unavoidably left in the burnt pyrites varies much according to circumstances; the amount practically obtainable as sulphurous acid (sulphur dioxide, SO_2) on the large scale depending on the nature of the ore, its texture and freedom from earthy matters, the per-centage of copper contained, the size and shape of the pyrites burners or kilns, the draught, the manner of stoking, removing burnt ore, and supplying fresh pyrites, the size of the lumps used and the quantity passed through the kiln per diem, &c., &c. When much lead is present the pyrites is more apt to flux wholly or partially; the lumps are thus more or less agglomerated or glazed, and the removal of the sulphur greatly hindered; if ores such as Wicklow pyrites (consisting of pyrites disseminated through a more or less compact slaty mass) be used it is difficult to ensure the combustion of the sulphur in the centre of the larger lumps; on breaking open such lumps the interior will frequently be found to be in a perfectly unburnt or "green" state. With careful stoking and selection of the lumps this may indeed be avoided to some extent, but it is almost impossible to prevent its occurrence altogether without interfering with the daily "duty" of the kilns used.

When other circumstances are favourable, the amount of sulphur left in fairly burnt cupreous pyrites (averaging from 3 to 4 per cent. of copper after burning) may be reduced to about 3 per cent. As 100 parts of "green ore" yield about 67 of "burnt ore" (the green ore not containing more than a few per cents. of earthy matter, and the per-centage of sulphur being from 48 to 50), it will follow that, out of 100 parts of sulphur originally used in the pyrites, about $\frac{67}{100} \times 3 \times \frac{100}{50} = 4$ parts will remain unburnt; thus, according to the writer's observations, the following was the average composition of burnt Huelva pyrites when produced on a moderately large scale (about 30 tons of pyrites burnt daily):—

	Composition of Green Ore.	Composition of Burnt Ore.
Iron	44·28	64·88
Sulphur	49·07	3·08
Copper	2·75	3·75
Arsenic	0·38	
Quartz and Silica	2·34	2·90
Oxygen and other matters undetermined	1·18	25·39
	100·00	100·00

During a different period, when a somewhat lesser quantity of pyrites was passed through the kilns per diem, the average per-centage of sulphur in the burnt pyrites was only

3·01,

whilst in another set of kilns of the same dimensions and shape, where still less ore was used per diem, the average per-centage of sulphur in the burnt pyrites was only

2·85.

The following table exhibits the influence of the rate at which the pyrites was employed on the average per-centage of sulphur contained in the burnt ore, the averages being in each case derived from the results of several months' working:—

Average Number of Cwts. of Pyrites per Kiln per diem.	Average Per-centage of Sulphur in Burnt Pyrites.
5·8	2·85
6·8	2·88
about 7·0	3·01
7·5	3·08

from which it is evident, as might be expected *à priori*, that the harder the kilns are "pressed" the larger is the per-centage of unburnt sulphur left in the pyrites.

In the case of Wicklow pyrites (slaty, containing from 26 to 33 per cent. of sulphur, averaging 30·9 per cent.) it is far more difficult to estimate the amount of sulphur that is lost from imperfect combustion; the writer found apparently well-burnt pyrites of this description contained of sulphur

4·88 per cent.

as an average of the ores burnt during fourteen months. Most of this, however, was contained as visibly unburnt cores of unaltered pyrites in the larger lumps, the small pieces and dust containing on an average only

2·73 per cent.

Similarly the burnt Wicklow pyrites produced during another period averaged

6·06 per cent. of sulphur.

Assuming 5 per cent. as an average of unburnt sulphur, as the green ore yields about 80 per cent. of its weight of burnt pyrites, the quantity of sulphur unburnt in the case of the above pyrites will be—

$\frac{80}{100} \times 5 \times \frac{100}{30·9} = 12·6$ parts per 100 of original sulphur;

so that the use of Huelva pyrites causes less than one-third of the loss of sulphur from imperfect combustion that is suffered when Wicklow pyrites is employed.

Viewed from another point of view, the varieties of pyrites

used in the manufacture of sulphuric acid may be divided into two classes, viz., those which contain an amount of copper worth extracting, and those which do not. When the amount of copper present is very small, or when that metal is absent, the burnt ore has but little value; if much earthy matter be present, the residue is rarely of service for anything but road-making; if, however, but small quantities of earthy substances be contained in the original pyrites, the burnt ore is applicable, and is occasionally employed, as a source of iron, being smelted along with clay ironstone or other iron ores. It is noticeable that no marked increase in the per-centage of sulphur contained in the pig-iron appears to be caused by the presence of the unburnt sulphur in the pyrites (at any rate when Cleveland clay ironstone is employed together with the burnt ore), such sulphur being mainly eliminated as sulphur compounds in the slag.

It frequently happens that the peroxide of iron contained in the burnt ore has a more or less bright red tint, so that by grinding and washing the material a pigment is obtained capable of use as a substitute for red lead, burnt umber, &c., &c., according to the shade.

A process for utilizing burnt pyrites containing so little copper as to be useless as a source of that metal was adopted by I. Lowthian Bell some years ago, but has since been discontinued from the circumstance that the price of pyrites itself has been so low as to render the process valueless in a pecuniary point of view. Should, however, the price of sulphur ores rise in future, this process affords a valuable means of utilizing not only the burnt pyrites, but also the *bête noire* of the alkali maker, vat-waste. The process as described by Mr. Bell ("Transactions of the Newcastle Chemical Society," 1869, p. 117) is as follows:—the process was patented in 1852:—

A blast-furnace 25 feet high and 10 feet across the widest part is charged with 4 parts coke, 3 of dry vat-waste (or as much moist waste as would represent this quantity of dry material), 1½ of burnt pyrites, and 2 parts of clay; about 1,200 to 1,500 cubic feet of air, previously heated to about 650° F. is forced in per minute at the tuyeres by a blowing engine, and the operations conducted in precisely the same way as the smelting of iron. It is necessary that the temperature should not rise too high, otherwise iron makes its appearance in the metallic state and not as sulphide, the production of which is the main object of the process; hence the whole of the iron is not thus obtained, a small portion being retained by the slag communicating to it a black colour. The oxide of iron, being deoxidized by the gases produced by the combustion of the coke, unites with the sulphur of the vat-waste forming a fuzible sulphide of iron which accumulates in a melted state at the bottom of the furnace; the earthy matters of the waste and the burnt pyrites, together with the constituents of the clay, unite, forming a fuzible slag of a vitreous fracture, and sufficiently hard to be used for road-making; this slag floats on the fused sulphide of iron, and continually runs away through a perforation in the furnace (slaghole). At suitable intervals the sulphide of iron, or *factitious pyrites*, is drawn off by tapping the furnace.

This factitious pyrites, when freshly fractured, has a deep bronze colour, and a metallic lustre with a somewhat crystalline structure; sometimes, however, it has a granular appearance, and is of a darker colour. Its average composition is—

Iron	65·0
Sulphur	31·8
Oxygen	4·1
	100·9

so that it consists essentially of sulphide of iron, FeS, with unaltered peroxide of iron. From this sulphide sulphurous acid is obtainable by burning it in a suitably constructed apparatus, the peroxide of iron resulting from the change being used over again in the blast furnace with fresh waste, or otherwise employed. Certain practical difficulties, however, are met with in the burning of this factitious pyrites. Being very hard and compact, it is difficult, if not impossible, to use it in the pyrites kilns by itself; and even when lumps of the factitious and of natural pyrites are employed together, it is very difficult to get more than one half of the sulphur from the former converted into sulphurous acid gas. To avoid this difficulty, the fused mass as it flows from the furnace can be received in water, whereby a black powder or slime is formed; this when formed into cakes and dried burns much more readily than the lumps, but still requires a peculiar mode of management in order to obtain successfully the sulphur from it. This improvement was patented in 1853.

Again, the interior lining of the blast furnace rapidly wears away, thus necessitating frequent stoppages for repairs. These circumstances taken together render the process less remunerative at the present price of pyrites. Viewed as a means of utilizing the sulphur contained in vat-waste, the process is not absolutely perfect, inasmuch as the resulting slag not only contains some iron, but also retains several per cents. of its weight of sulphur. Thus the following analyses indicate its general composition:—

	1.	2.	3.
Silica	40·0	36·8	46·0
Lime	27·7	35·6	24·4
Alumina	18·0	23·2	15·6
Iron	8·9	1·4	7·6
Sulphur	4·9	4·5	2·4
	99·5	101·5	96·0

whilst the average of several consecutive days' working gave these per-centages:—

Iron	2·2 to 2·7
Sulphur	3·0 or rather less.

In 1854 W. J. Cookson patented a process for reducing lead ores (galena) to the metallic state by means of the impure metallic iron obtained by heating burnt pyrites with carbonaceous matter; the galena is mixed with a small quantity of alkali (to facilitate the fusion) and a suitable proportion of burnt pyrites and carbonaceous matter; metallic lead and sulphide of iron are then formed when the mass is heated. The sulphide of iron thus produced is thus treated in much the same way as the "factitious pyrites" of Bell above described, or is treated with hydrochloric acid so as to evolve sulphuretted hydrogen, which is then burnt as in Gossage's process.

Another use to which burnt pyrites has been put was suggested by Kuhlmann. If mixed with about a quarter of its weight of pitch from the distillation of coal tar (the pitch being melted, and the burnt pyrites incorporated and well mixed while still fluid), a substance is produced which sets to a hard mass on cooling, and can be employed as a substitute for asphalte paving, &c.

By far the most important application of roasted pyrites, however, is that which consists essentially in extracting the copper which is contained, and leaving behind a residue of more or less pure oxide of iron capable of use as a source of that metal. Previously to the introduction of what is known as "Henderson's process," numerous attempts had been made to obtain the copper from pyrites in which it occurred in small quantities. When the amount contained was not too small the ordinary methods employed in copper metallurgy were available; the ore was smelted in a cupola furnace whereby a slag almost free from copper was obtained, and also a copper regulus, or *coarse metal*, consisting mainly of copper and iron sulphides, from which the purified metal (*refined copper*) was obtained by the ordinary processes; or, preferably, the burnt pyrites was mixed with other copper ores of the same kind but containing more copper, and similarly treated.

In 1840 Cookson took out a patent for obtaining copper by means of a regulated roasting of the cupreous pyrites, the sulphur associated with the iron being burnt off, leaving an oxide of iron, and that combined with the copper being left unaltered; this copper sulphide is then calcined at such a temperature that it takes up oxygen, becoming converted into sulphate of copper, which is then dissolved out, and either crystallized and sold as "blue vitriol," or dried and converted into metallic copper by heating with the equivalent quantity of copper sulphide in close vessels. An improved furnace for effecting this calcination was patented by T. Richardson in 1858.

Monier has quite recently proposed a modification of this process, viz., roasting the cupreous pyrites with soda, whereby sulphates of sodium, copper, and iron, are formed. The resulting mixture being further heated, the iron sulphate is decomposed, the other sulphates being unaltered; these are then dissolved out by water and separated more or less by crystallization; the resulting copper sulphate crystals are heated to redness with small coal, and the resulting mixture of copper oxide and metallic copper reduced and refined as usual. It is stated that out of 85lbs. of copper contained in a ton of pyrites 82½lbs. are obtainable in the metallic form by this process, only 2½lbs. being lost.

In 1859 Leister patented the following process: The pyrites, burnt until nearly all the sulphur is expelled, is digested with hydrochloric acid (20 or 25lbs. to the ton); the resulting liquors contain much chloride of copper, which is run off and precipitated by scrap iron; the resulting protochloride of iron is mixed with fresh hydrochloric acid, exposed to the air to peroxidize it, and used over again, the presence of the iron salt apparently increasing the solvent action. Or the burnt pyrites is moistened with solution of chloride of iron, or with hydrochloric acid, and then weathered for some time (several months in some cases) until all the copper is oxidized: sulphuric acid may be also used in place of hydrochloric acid.

In 1861 (Patent No. 42) G. D. Mease proposed to use the waste acid, chloride of manganese, produced in the manufacture of chlorine and bleaching powder, instead of hydrochloric acid as proposed by Leister, and, in the same year (Patent No. 1869), Haeffely proposed the same thing, employing a series of lixiviation tanks like those in use in the alkali manufacture; at the end of a week all the copper contained in the burnt pyrites used is in solution. Haeffely proposed to precipitate this as sulphide by the addition of vat-waste, so that his improved process would get rid of three waste substances at once—vat-waste, still-liquor, and burnt pyrites. The sulphide of copper is then either oxidized to sulphate, and the resulting blue vitriol crystallized, or it is reduced and refined so as to extract the metal. In reference to the processes of Leister and Haeffely, the writer conducted, some little time ago, a number of experiments, from which it appeared that the *modus operandi* is, at any rate partially, as follows: the action of the free hydrochloric acid contained in the still-liquor, or added as such, on the peroxide of iron in the burnt pyrites, necessarily forms perchloride of iron; when this substance in solution is digested with copper sulphide (the state of combination in which the copper mostly exists in ordinary burnt pyrites) the copper becomes partially converted into copper chloride, which is dissolved, the associated sulphur being oxidized, so as to form sulphuric acid. Simultaneously the perchloride of iron is more or less reduced to protochloride. Free access of air during the digestion shortens the process considerably, as it causes the partial re-conversion of protochloride of iron into perchloride. In three days' time 80 per cent. of the original copper sulphide is converted into chloride (in the case of a burnt cupreous pyrites containing 6·5 per cent. of copper), the temperature being that of the air; but if the liquor be artificially heated the action is much more rapid. Thus, when the liquors were heated to boiling, allowed to digest a few hours (while cooling,) and the process repeated three times with fresh liquor, 94 per cent. of the original copper was dissolved out in two days. Of course the process of precipitation by metallic iron is preferable to that proposed by Haeffely, metallic copper being thus obtained directly from the liquors.

Besides these, numerous patents have been taken out from time to time for improvements in these processes or modifications of them, or adaptations of the principles involved to either or to special varieties of ores; but the only process which appears to have succeeded in practice, or at all events to have come into anything like general use, is the one previously alluded to, and which bears the name of William Henderson.

A series of patents have been taken out by Henderson since 1857, which all bear, more or less, on the subject, and in each of which some important improvement or adaptation of previous inventions is described. The process as now practically at work may be thus described:—

The ores employed are mostly of Spanish and Portuguese origin, derived from the Huelva and Tharsis mines; the larger lumps of ore are broken up by a crushing machine, or by hand, into pieces of from 2 to 5 centimetres diameter; these are passed through a sieve so as to separate the finer portions, which are either roasted in a separate furnace (not unlike a blind saltcake furnace), or are made up into balls or cakes with water, clay, &c., and burnt along with the larger lumps or in separate kilns. The larger sorted lumps are then added gradually to the kilns, the dimensions of which vary, but are usually from 1·2 to 1·7 metres square. From 250 to 350 kilogrammes (from 5 to 7 cwts.) of pyrites are thus burnt daily per kiln, according to its size, the burnt pyrites being drawn out at bottom (by means of "rotating bars," about 32 to 52 millimetres apart), and containing between 3 and 6 per cent. of sulphur, the amount left being preferably half as much again as the quantity of copper contained. When the burnt pyrites used has been so far roasted that the amount of sulphur contained is less than this amount in reference to the copper, the total quantity of sulphur in the mixture finally employed is brought up to this normal amount by addition of siftings, &c., of unburnt cupreous pyrites, or by properly mixing with burnt pyrites which contains an excess of sulphur in reference to the copper present; the lumps are then passed through a crushing machine, and the resulting coarse powder mixed with as much pulverized rocksalt as represents about four times the quantity of copper present (4 per cent. copper requires 15 per cent. of rocksalt). Usually the salt is added in lumps before passing through the crushing machine, and is thus reduced to powder along with the pyrites.

The mixture is then roasted for about six hours in a suitable furnace until the following actions have taken place: oxygen being taken up by the copper sulphide present (from the heated air in contact with the mixture), the sodium chloride re-acts on the nascent copper sulphate, producing sodium sulphate and copper chloride. The excess of sulphur present over that combined with the copper similarly acts on the peroxide of iron and the oxygen of the air, thus forming, with the help of more sodium chloride, sulphate of sodium and chloride of iron, with more or less hydrochloric acid gas. The furnaces employed for this purpose vary in construction: in some instances muffle furnaces, similar to the blind furnaces used in making saltcake, are employed; these are usually heated directly by the flame from an adjoining fireplace. In other cases the furnace is heated by the gases given off from a separate gas generating furnace, whilst in others, again, a furnace with rotating hearth is employed. Of these three, the second form appears to be the most convenient, and, moreover, a larger amount of material can be heated per diem in a furnace of this description than in the muffle furnace, with direct firing. The rotating furnace, however, enables a still larger amount of material to be dealt with in a given time, and requires less manual labour.

At the end of about six hours' roasting (the temperature being such that the brickwork is barely visibly red hot for the first two hours, and not so hot during the last two or three hours), about three-fourths of the copper present has become changed into chloride, soluble in water, most of the remainder being soluble in hydrochloric acid. Should the temperature be too high at the close of the operation, however, a considerable quantity of the copper chloride is partially decomposed, yielding a substance (basic chloride?) insoluble in water. The progress of the roasting is judged from time to time by taking out average samples from different parts of the hearth, treating them successively with water and hydrochloric acid, to remove the soluble copper compounds formed, and finally dissolving the insoluble part in nitric acid, and supersaturating with ammonia. The depth of the blue tint produced (care being taken to employ the same weight of sample and to dilute to the same volume in each case) affords a fair index of the amount of copper sulphide yet unacted on, the tints being compared with those of standards prepared for the purpose.

During the roasting the charge is stirred from time to time with a paddle or rake, whereby jets of blueish flame are produced, the colour being probably due to copper chloride vapours, or possibly to sulphur. If the percentage of copper contained were higher than 6·0 the time of roasting would require to be much prolonged; it is found more convenient to mix pyrites of various per-centages of copper, so as to diminish the amount contained in the richer varieties.

The hydrochloric acid gas produced during the process is led away into coke towers about 12 metres high, and condensed by water, as in the manufacture of saltcake. Even if the temperature of the furnace be carefully regulated, a certain amount of copper chloride is carried over in the form of vapour, and condenses with the hydrochloric acid. The amount thus regained from the tower liquors is, however, but small when the roasting is properly performed. Thus, Phillips obtained only two tons of copper from these liquors during a period when 800 tons of copper were made altogether. The copper regained from these liquors is uniformly very impure, much antimony and arsenic chlorides, &c., being formed during the roasting, and condensed along with the hydrochloric acid.

The roasted mass is then lixiviated in tanks constructed of well tarred wood or of slabs of stone, water at 50° or 60° being used at first (the solution thus obtained yields a very pure precipitated copper, containing 95 per cent. of the silver originally present in the ore). The solutions thus obtained are drawn off (usually through a perforated false bottom, like that in the tanks used for the lixiviation of blackash in the soda manufacture); the weakest solutions are employed instead of fresh water, so that the copper shall be extracted as perfectly as possible by the aid of as little water as possible. The residue left after three such washings is then washed several times with the acid liquor that condenses in the towers, or with hydrochloric acid. The copper finally obtained from the washings where the tower liquors are employed is considerably less pure than that obtained from the water washings, being contaminated with arsenic, antimony, &c. Six washings with acid are usually given, at the end of which time all the copper that can be economically extracted has been dissolved out. The residue that is left (consisting mostly of peroxide of iron with siliceous and earthy matters, &c., pre-existing in the pyrites) is sold to iron refiners under the name of "purple ore," or "blue billy;" being somewhat refractory, it forms a good substitute for hæmatite, &c., in the lining (*fettling*) of puddling furnaces. It usually contains from 0·08 to 0·20 per cent. of copper and 0·16 to 0·25 per cent. of sulphur. Frequently the purple ore is used on the premises, being heated with small coal in a furnace, so as to reduce the oxide of iron to the state of spongy metal, which is then used instead of scrap iron to precipitate copper from the solutions of its chloride thus obtained. Thus spongy iron acts (as might be expected) much more rapidly than compact masses. The use of the spongy iron thus obtained was patented by Gustav Bischof in 1862 (Patent No. 1,235),

it being alleged that the copper is *immediately* thrown down from solution, whereas arsenic, if present, is only precipitated after the lapse of some hours ; whilst the process of obtaining malleable iron from the comparatively pure oxide of iron got by Henderson's process was patented by Henderson in the same year (Patent No. 3,438).

The precipitation tanks are conveniently made of tarred wood or stone, about 2·5 to 3 metres long, 1·5 to 1·9 broad, and 1·25 meter deep. Scrap iron or reduced ore being added to the copper leys heated by the introduction of steam, a pulverulent copper of greater or less purity is thrown down, which is either sold as such or refined on the premises.

The liquors obtained by adding water to the roasted mixture of ore and salt contain a considerable excess of sodium chloride, which retains in solution most of the silver originally contained in the ore, together with the gold ; this is preferably extracted by Claudet's process (*vide* "Practical Magazine," No. 1, p. 47).

The solution obtained after the precipitation of the copper is usually thrown away ; sulphate of soda and oxide of iron can, however, be obtained from it by evaporation and crystallization, &c. The extraction of sulphate of soda by this means was patented by J. A. West, in 1860 (Patent No. 2,483).

The precipitated copper thus obtained, contains from 75 to 95 per cent. of metal. The purer specimens obtained from the aqueous solutions can be directly refined, but those from the acid liquors are converted into regulus by heating with crude ore or with vat-waste, this regulus being subsequently refined in the usual way. During the earlier history of the copper extraction process, some prejudice existed in the minds of copper refiners against the precipitated copper obtained by this process. It was stated that copper of first-class qualities could not be refined from such a material, and that the copper was wholly unsuitable for making brass. Most of the objections, however, appear to have been met ; the inferiority of the copper being due in all probability to the presence of small quantities of foreign metals, which is now avoided for the most part either by suitably choosing the ores employed, or by appropriately modifying the processes adopted.

The following rough estimate was furnished to the writer some time ago as to the plant, working expenses, &c., necessary for the extraction of the copper from 150 tons of burnt pyrites weekly, the pyrites being bought as containing 3¼ per cent. of copper. In many respects it can only be taken as approximately correct, especially in the items of labour and fuel :—

Special Plant required :—

Sheds and chimney.
Engine and mill.
4 Calcining furnaces (muffle furnaces).
1 Condensing tower.
5 Lixiviation tanks.
3 Precipitation do.
Boilers for heating lixiviating water.

Working Expenses per week :—	£	s.	d.
1 Foreman	1	15	0
1 Watchman	1	4	6
1 Engineer, 3*s.* per day	0	18	0
8 Calciners	6	0	0
1 Labourer in mill	0	14	0
2 Do. for mixing	1	8	0
2 Do. calcining	1	8	0
3 Do. for vats	2	2	0
2 Do. yard	1	8	0
	£16	17	6

Fuel per week :—

Engine and heating boilers	12 tons.
8 Calciners : each 6 tons	48 „
	60 „

Total weekly Cost :—	£	s.	d.
Fuel : 60 tons at 4*s.* per ton (?)	12	0	0
Labour	16	17	6
150 tons pyrites at £2 9*s.*	367	10	0
19 tons salt at 9*s.*	8	11	0
4¾ tons scrap iron at £3 10*s.*	16	12	6
Total cost	£421	11	0

Produce :—

7½ tons of precipitated copper at 70 % copper, at £59 10*s.* per ton, or 17*s.* per unit	446	5	0
100 tons purple ore, at 5*s.*	25	0	0
	£471	5	0

	£	s.	d.
Cost of working	421	11	0
Wear and tear, Profit	49	14	0
	£471	5	0

The following brief notices of patents relating to this subject may be of some historical interest. They represent most of the more important patents taken out in Great Britain, between 1730 and 1863, on the subject of the treatment of pyrites and analogous substances, for the manufacture of sulphuric acid, and the extraction of metals, &c., from the residues left in that process. It is noticeable that in many cases precisely the same process has been patented by or embodied in the specifications of different patentees.

1730, Nov. 7. SAMUEL HUTCHINS. No. 523. A method of extracting and preserving the sulphur contained in Mundic, &c., by which this sulphur may be prepared so as to answer the end of that imported from abroad.

1738, Sept. 18. WILLIAM CHAMPION. No. 564. A method or invention for the reducing of sulphurous British mineral and minerals into a body of metallic sulphur.

1778, Feb. 9. MATTHEW SANDERSON. No. 1,203. New process for the extracting a mineral sulphur from pyrites, copper, and lead ores, separating its acid, and rendering it useful for every medicinal purpose.

This amounts to a rough method of distilling off a portion of the sulphur contained in natural sulphides.

1780, May 9. MATTHEW SANDERSON. No. 1,243. New process for extracting from lead glitter, &c., alum, sulphur, &c. ; refining and separating their metallic contents by a blast furnace, &c.

1818, Nov. 17. J. HILLS and M. HADDOCK. No. 4,263. Improvement in the manufacture of sulphuric acid.

Use of a peculiar furnace.

1838, May 8. WILLIAM GOSSAGE. No. 7,636. Certain improvements in manufacturing sulphuric acid.

As mentioned above, sulphur is burnt off till ferrous sulphide is left ; this is then treated with hydrochloric acid, and the evolved sulphuretted hydrogen burnt.

1838, Aug. 31. J. KEYS and W. T. CLOUGH. No. 7,793. A method for the manufacture of sulphuric acid from copper ore, copper regulus, and sulphuret of zinc.

These ores are treated like ordinary pyrites.

1839, June 6. H. G. DYAR and J. CHISHOLM. No. 8,094. Improvements in obtaining sulphur from pyrites or certain native sulphurets.

1839, July 11. E. F. J. DUCLOS. No. 8,149. Improvements in the manufacture of sulphur, sulphuric acid, and sulphate of soda.

As mentioned above, the patentee converts the protosulphide of iron formed by partially burning the pyrites into sulphate of iron (by roasting), and then heats this so as to expel concentrated sulphuric acid.

1840, Jan. 5. W. J. COOKSON. No. 8,374. Certain improved processes or operations for obtaining copper and other metals.

As mentioned above, the copper is converted into sulphate by a properly regulated roasting.

1840. Feb. 25. THOMAS FARMER. No. 8,398. Improvements in treating pyrites and other matters to obtain sulphur, sulphurous acid, and other products.

An improved kiln.

1840, April 6. H. BLAIR and H. H. WATSON. No. 8,465. Certain improvements in the manufacture of sulphuric acid, &c.

1840, July 8. JAMES HARVEY. No. 8,562. Improvements in extracting sulphur from pyrites and other substances containing the same.

1840. April 5. F. HILLS and G. HILLS. No. 8,925. Certain improvements in the manufacture of sulphuric acid and carbonate of soda.

An improved kiln.

1843, Jan. 12. J. E. W. RODGERS. No. 9,586. Certain improvements in the separation of sulphur from various metallic substances.

Steam is led into the pyrites burner so as to form sulphuretted hydrogen, which is then burnt to sulphurous acid, or partially burnt, so as to remove the hydrogen and set sulphur free.

1843, Oct. 18. JAMES GRAHAM. No. 9,912. Improvements in the construction of pots or vessels and furnaces used in the manufacture of zinc, &c.

Production of sulphuric acid from zinc blende by roasting.

1843, Dec. 5. W. NEWTON. No. 9,974. Improvements in extracting certain metals from ores, some part or parts of which improvements are also applicable to obtaining another product, &c., from such ores or compounds.

A peculiar calcining furnace. Sulphur is obtained from the

sulphurous acid by the action of red-hot coke or a carburetted hydrogen.

1844, Dec. 4. J. C. GAMBLE. No. 10,416. Improvements in the manufacture of sulphuric acid.

The heat generated in the pyrites kiln is employed to evaporate acid solutions, &c.

1846, July 23. THOMAS BELL. No. 11,307. Improvements in the smelting of copper ores.

1847, Nov. 16. W. BIRKMYRE. No. 11,966. Improvements in smelting copper and other ores.

1850, Feb. 27. B. TODD. No. 12,982. Improvements in the manufacture of arsenic, sulphuric acid, &c.

Uses a blast furnace to roast pyrites.

1852, March 8. JAMES GRAHAM. No. 13,999. Improvements in treating ores containing zinc, and the products obtained therefrom.

A peculiar roaster for zinc blende, so as to obtain sulphurous acid.

1852, Nov. 15. J. COWEN and T. RICHARDSON. No. 746. Improvements in the manufacture of sulphuric acid.

A bench of D-shaped retorts, with external heat, used for roasting metallic sulphides.

1852, Nov. 17. J. L. BELL. No. 772. Improvement in the treatment of certain compounds of iron and sulphur.

The manufacture of "factitious pyrites" described above.

1853, Jan. 8. W. HENDERSON. No. 57. Improvements in manufacturing sulphuric acid, &c.

Utilizes the sulphurous fumes from roasting of copper ores by peculiar arrangement of kilns, &c.

1853, Sept. 9. J. L. BELL. No. 2,079. Improvement in the manufacture of sulphuric acid.

The improvement in the mode of treating factitious pyrites mentioned above.

1853, Aug. 11. H. L. PATTINSON. No. 1,877. Improvements in the recovery of sulphur from alkali waste.

This is a modification of J. L. Bell's process for obtaining "factitious pyrites," where maganese is used instead of iron, producing manganese sulphide.

1853, Oct. 10. H. L. PATTINSON. No. 2,321. Improvements in the manufacture of sulphuric acid.

"Factitious pyrites" is mixed with sulphur and some plastic substance, ground to powder, mixed with water, and the resulting paste made into cakes, dried and burnt.

1854, March 8. W. J. COOKSON. No. 553. An improvement in the reduction of lead ores.

As described above, a sort of "factitious pyrites" is obtained by roasting galena, burnt pyrites and carbonaceous matter, metallic lead being set free.

1854, March 15. ALFRED TRUEMANN. No. 622. An improved furnace for the calcination of copper ores and other mineral substances.

The ore is gradually moved from one end of the retort to the other by means of an Archimedean screw, several retorts at different temperatures being connected and the ore passed successively through all.[1]

1854, July 25. PETER SPENCE. No. 1,632. Improvements in obtaining sulphur from iron pyrites, and other substances containing sulphur, and an apparatus for effecting the same.

The sulphurous acid formed is led through a mass of coke contained in pipes, heated to redness by the burning pyrites; sulphur is thus set free.

1854, Sept. 22. PETER SPENCE. No. 2,047. Improvements in obtaining sulphur from iron pyrites and other substances containing sulphur.

Alternate layers of pyrites and coke employed instead of pipes filled with coke, as in previous patent.

1854, Dec. 14. L. W. EVANS and J. MCBRYDE. No. 2,632. Certain improvements in the burning of sulphuret ores for making sulphuric acid, and for smelting.

Air is forced into close pyrites kilns.

1855, Oct. 13. M. P. LOZANO. No. 2,297. Improvements in treating pyrites and ores containing sulphur; in obtaining sulphuretted hydrogen, and in precipitating copper from solutions.

1856, Aug. 20. W. GOSSAGE. No. 1,947. Improvements in obtaining sulphur and metals from certain ores and other compounds of metals.

Air is forced through the fused sulphide so as to burn off sulphur and leave crude metal.

1856, Sept. 18. ISHAM BAGGS. No. 2,183. Improvements in smelting or reducing copper and other metals from their ores and in the manufacture of sulphuric acid in or by such processes.

1857, Jan. 13. A. V. NEWTON. No. 1,665. An improvement in the manufacture of sulphuric acid.

The powdered sulphide is mixed with caustic soda and other salts, made into bricks, and burnt after drying.

1857, July 6. F. C. HILLS. No. 1,873. Improvements in the manufacture of sulphuric acid.

A peculiar burner for pyrites.

1857. W. HENDERSON. No. 2,517. Ores containing copper as oxide are dissolved in hydrochloric acid of specific gravity 1·025 to 1·050, if 2½ per cent. of copper be present; stronger acid being used if the per-centage be higher. The lixiviation is conducted as in the alkali process. Iron is peroxidized by chlorine, and the liquor then digested with carbonate of lime *in the cold*. Peroxide of iron is then thrown down. The resulting clear green liquor is syphoned off and then *heated* with more carbonate of lime, whereby oxide of copper is precipitated. Or scrap iron may be used to throw down the copper.

Ores containing sulphur are thoroughly calcined and then treated as above.

1857, Nov. 10. J. TOWNSEND. No. 2,839. Improvements in the manufacture or production of sulphurous acid.

Sulphides mixed with alkaline or earthy sulphates, sulphites or hyposulphites are used in the kilns.

1858, Jan. 30. J. A. BOUCK. No. 174. Improvements in the manufacture of sulphate of copper, &c.

Copper pyrites is roasted until the copper becomes converted into sulphate.

1858, May 17. J. ALLEN and W. ALLEN. No. 1,094. Improvements in treating copper and iron pyrites, and the apparatus for the same.

A downward current of air is employed in the kilns; also in the cupola furnaces used for smelting burnt cupreous pyrites.

1858. C. CROCKFORD. No. 1,376. Improvements in the treatment of the ores of zinc, &c.

A peculiar furnace for obtaining sulphurous acid from zinc blende.

1859. LEISTER. No. 264. Treats pyrites with hydrochloric acid, to drive out the copper. Mentioned above.

1859. THOMAS RICHARDSON. No. 1,930. A method of treating copper ores.

1859, Sept. 16. T. RICHARDSON. No. 2,110. Improvements in the manufacture of sulphuric acid.

A peculiar furnace for burning coalbrasses.

1859, Dec. 20. W. HENDERSON. No. 2,900. Improvements in treating certain ores and alloys, and in obtaining products therefrom.

Employs a mixture of salt and impure sulphide of copper to obtain chloride of copper as above described. Obtains sulphate of copper by treating copper ores with sulphuric acid, and heats the sulphates of metal so as to expel sulphuric acid.

1859. ROBERT MCCALL. No. 2,128. Adds magnetic oxide of iron to liquors containing copper, whereby metallic copper is thrown down and a yellow ochre produced.

1860. LAWRENS. No. 153. Obtains chlorine from chloride of copper by heating it so as to form subchloride and free chlorine. The subchloride is dissolved in hydrochloric acid and used over again.

1860. THOMAS RICHARDSON. No. 1,930. Passes sulphurous acid up a tower containing burnt pyrites, whereby sulphate of iron is obtained, and also a peroxide of iron suitable for gas purification.

1860. JOHN AARON WEST. No. 2,483. Extracts sulphate of soda from the liquor obtained in Henderson's process, mentioned above.

1861. G. D. MEASE. No. 42. Burns poor copper ores containing sulphur with the aid of steam, producing sulphate of copper and peroxide of iron, or heats them on trays in the current of mixed nitrous and sulphurous acids, obtained in the vitriol manufacture, so as to produce sulphate of copper; also, as above mentioned, dissolves out copper by means of chloride of iron, waste manganese liquor, or hydrochloric acid, or by adding water to the roasted mixture of ore and common salt.

1861. ROBERT LAING and ISRAEL SWINDELLS. No. 1,084. Copper ores are calcined and lixiviated with water; the residues are placed in towers, up which gaseous sulphurous or hydrochloric acid gas is passed, whereby copper is dissolved out.

The patentees claim the use of *gases*.

1861. NEWTON. No. 1,117. Heats copper pyrites with sulphur and chloride of lime (?) or other chlorides, so as to obtain a purer sulphide of copper.

1861. P. SPENCE. Nos. 1,695 and 3,002. P. SPENCE and J. MELLOR. No. 1,958 (also 1860. No. 2,702). Various improvements in the method of extraction of copper from pyrites, furnaces for roasting, &c. &c.

[1] During the last two or three years the idea here embodied has been patented for the manufacture of gas from coal, and for the separation of solids, paraffins, &c., from petroleum, coal oils, &c., the vessel being cooled in the latter case instead of heated.

1861. EDWARD HAEFFELY. No. 1,869. Uses waste manganese chloride as described above, and as previously proposed by Mease; also precipitates copper as sulphide by vat-waste.

1861, Oct. 28. E. MCCLINTOCK. No. 2,695. Employs copper in the process of blackash making, and burns the copper sulphide formed so as to obtain sulphurous acid.

1862. G. BISCHOF. No. 581. Converts copper sulphate into chloride by addition of calcium chloride, and precipitates oxide of copper by lime, magnesia, baryta, &c.; if iron is present a mixed precipitate of oxide of iron and copper is thrown down, from which the copper can be dissolved out by digesting with the mixed chloride of these metals, oxide of iron being separated.

1862. G. BISCHOF. No. 1,235. Heats burnt pyrites with coal dust, &c., so as to get spongy iron used for precipitating copper as above described. If silver is present, previously throws it down as *chloride*.

1862. BALTASAR GARLAND. No. 1,743. Obtains sulphate of copper from burnt copper ores, &c., by treating with sulphuric acid, &c.; calcining to decompose sulphate of iron; and precipitating residual iron in the solution by means of malachite or oxide of copper; crystallizes out blue vitriol and obtains nickel and cobalt from the mother liquors by processes previously patented (1856, No. 2,922; 1857, No. 1,589; 1861, No. 3,076).

1862. THEODORE FLEITMAN. No. 2,483. Obtains sulphide of copper from copper ores, and treats it with alkaline solutions, obtaining oxide of copper, which is then smelted.

1862. W. HENDERSON. No. 3,438. Obtains malleable iron from the "blue billy" obtained by his process, as above described.

1863, April 4th. P. SPENCE. No. 863. Passes waste gases containing sulphurous acid through cakes of spongy iron, whereby the sulphurous acid is absorbed and sulphate of iron formed.

1863. R. C. CLAPHAM. No. 967. Still liquors are subjected to distillation to recover free hydrochloric acid. When treated with burnt pyrites sulphur (?) is expelled, or they may be used to convert soda waste into hyposulphites.

C. R. A. WRIGHT.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(34.)

MEMORANDA on Timber. Seasoning and Preservation.—(*a.*) *Seasoning.*—Timber thoroughly well seasoned is in that condition in which its good qualities will be preserved, so that in one sense the seasoning and preservation of timber may be taken as the same terms. But timber may be well seasoned, and yet we may place it in such unfavourable conditions that it loses the good properties it may possess, and begins to decay. The terms "seasoning" therefore may be accepted as indicating the process by which we give timber good qualities, that of "preservation," the process or means adopted by which we retain in it those properties.

Seasoning.—The oldest and most generally adopted method of "seasoning" timber, is steeping or immersing it in water. This method is based upon the fact that by placing the timber in water, the sap is washed out of the pores and the water takes its place, which when the timber is afterwards exposed to the atmosphere, is much more easily and quickly expelled by evaporation from the timber, than the sap in the ordinary or natural condition. To obtain the best results of this mode of seasoning in the quickest way, two things are essential; the water must be running water, and it must be as pure as possible.

"Natural seasoning" is simply exposing the timber to the air, under sheds or otherwise piled up.

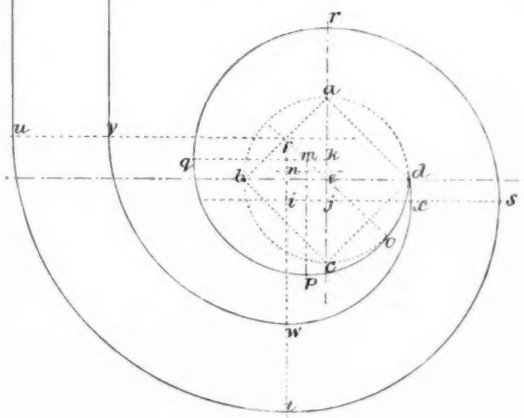
(*b.*) *Preservation of Timber.*—The most generally adopted mode of preserving timber after it has been, or is supposed to be, seasoned, is painting its outer surface. That this is effective only under certain circumstances we all know, for paint itself under the action of the atmosphere rapidly decays, exposing the timber to the action of the same. Coal-tar is a good preservative. It is much more lasting when mixed with sharp river sand, which may either be mixed with the tar and the mixture painted on, or the tar may first be put on, and the sand strewed over the surface, while the tar is hot. It is best to use the two modes in conjunction—that is, putting a small quantity of sand in the tar, in the first instance, and painting the surface, and finishing by strewing the sand over the whole. The same method of using sand may be adopted with ordinary paint. In preventing the attacks of fungi on wood, a paint made of 100 parts of flour of sulphur, 15 parts of linseed oil, and 64 of manganese, has been used with effect. A surface preservative is highly spoken of. It is made as follows:—Linseed oil 15 parts, resin 15, tar 5, white lead 12, any colouring material 4, cement 6, oxide of iron, glue 2, hydrate of chalk, lard 5, litharge 2. The whole to be boiled and reduced to one-tenth of the original bulk, and applied hot. The carbonizing or charring of timber, as in the case of the feet of posts which are to be inserted in the ground, is a good method of preserving it. A process has been recently patented for charring the surfaces of joists, &c., used in building.

In Bethell's process of preserving timber the heavy oil of tar, in which creosote is largely present, is employed. The substance coagulates the albuminous matter found in timber, and hardening, it partly increases the strength of the woody fibre, and as the oils are insoluble they cannot wash out of the timber. Further, their action is such that they effectually prevent worms from attacking it, they absorb the oxygen by which decay is promoted, and they also resinify the interior pores, preventing access of air, and are obnoxious to all fungi and animal parasites. From the colour and objectionable smell, however, which the oil imparts to the timber, the process is only available for outside work. The patented process is rather complicated, but for all ordinary purposes the plan of simply steeping the timber in the oil in a tank made for the purpose will be amply available. The timber should be dried before it is put into the tank, in which it should be allowed to remain for twenty-four or thirty-six hours, according to circumstances. The oil should be made hot in a pan or small boiler. This process of immersion will be found very useful, but where it cannot be carried out, much of its advantage will be obtained by simply painting the surface of well-seasoned timber with the oil. This will make the timber last longer than if this painting be not done.

(35.) Spiral Scrolls and Volutes, and how to describe them.

(See "Note" 8, p. 126, and "Note" 25, p. 186.—(*a.*) *To describe the scroll in fig.* 128.—Describe

Fig. 128.



the circle as *a b c d*, equal to the eye of the scroll, and within it a lozenge-shaped square, *a b c d*, by drawing the diameter *c a* at right angles to *b d*, and joining the points *a b*, *b c*, *c d*, *d a*. Divide the side *b a* into two equal parts in the point *f*, and perpendicular to the line *b d* draw a line *f t*. The drawing is to a scale of one-fourth full size. The centres are as follows: *f* is the *f* or sixth centre, the fifth centre is found by taking a distance of one and a-half inches, and measuring from *f* to *i*; the fourth centre is found by drawing a line *i j*, cutting the line *i s* in *j*; or a distance from *i* to *j* of one inch from the scroll. The third centre is at the point *k*, equal from the point *j* to the distance *i j*. The second centre is at the point *m*, and is found by dividing the distance *e k* into two equal parts, and setting one part from *k* to *m*. Another method of describing the scroll in fig. 128 is by dividing the diameter *a c* of the circle *a b c d* into four equal parts, and from the point *f*—the method of finding this point *f* we have already described—set off on the line *f t*, a dis-

tance equal to three of the parts in *a c*, as *f i*, from *i* to *j*, a distance equal to two of the parts in *a c*, from *j* to *k* the like distance, from *k* to *m* one of the parts, as *a c*, and from *m* to *n* half a part. The centres thus being found by either one or the other of the above methods, the describing of the curve of the scroll is done as follows. Through the points *f* and *e* draw a line, cutting the circle *a b c d*, fig. 128, in the point *o*, put in part of the circle from *o* to *d*, as described from the centre *e*. From the point *n*, as centre with distance *n o* as radius, describe the arc of the circle *o p*, cutting and terminating at a point *p* on the line *m p*, drawn parallel to *a c*. Next from the point *m* as a centre, with distance *m p* as radius, describe the arc *p q*, cutting and terminating at a point *q*, on the line drawn from *m* to *q*, parallel to *i s*. Then from the point *k* as a centre, with the distance *k q* as radius, describe the arc *q r*, cutting and terminating on line *k r*, drawn parallel to *a c*, at the point *r*. Next from the point *j* as a centre, with the distance *j r* as radius, describe the arc *r s*, cutting the line *j s* at the point *s*. Then from the point *c* as a centre, with the distance *i s* as radius, describe the arc, cutting the line *i t*, drawn parallel to *a c*, from the point *f* as a centre, with the distance *f t* as radius, describe the arc *t u*, cutting the line *f v u*. Finally, set off in the line *u f*, the distance *u v* equal to the breadth of the rail; and from the point *f* as a centre, with *f v* as radius, describe the arc *v w*, from *i* as a centre, with distance *i w* as radius, describe the arc *i w x*; and from *j* as a centre, with distance *j x* as radius, describe the arc *x d*, and the scroll is complete.

(*b.*) *To describe the "Volute" Spiral, as in fig.* 129.—Let *a b* be the radius of the circle which forms the eye of the volute or scroll. Divide *a b* into eight equal parts. From *a* set off one of these to the point 1 in the line *b a*. Through 1 draw at right angles to *a b* the line 1 2, and make 1 2 equal to *a* 1. Through 2, parallel to *a b*, draw the line 2 3, and make 2 3 equal to two of the parts in *a b*, or twice that of *a* 1. From 3 draw parallel to 1 2 the line 3 4, and make 3 4 equal to 2 3. From 4 draw parallel to 2 3 the line 4 5, and make the distance 4 5 equal to three of the parts on *a b*, the distance 5 6 is equal to four of the parts; thus any number of centres may thus be found. Next, to describe the arcs forming the curve of the scroll. From the point 1 as centre, with 1 *b* as radius, describe the arc *b c*, cutting a line drawn from 1 at right angles to *a b*. From point 2 as a centre, with distance 2 *c* as radius, describe the arc *c d*, cutting

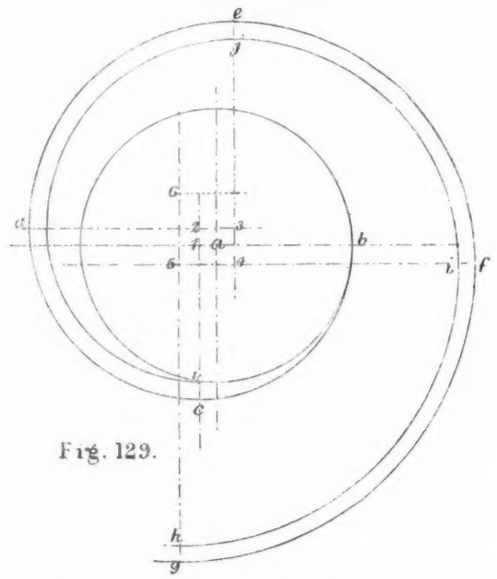


Fig. 129.

the line *d* 2 drawn parallel to *a b*. From the point 3 as a centre with distance 3 *d*, describe the arc *d e*, cutting the line 3 *e* From the point 4 as centre, with distance 4 *e*, describe the arc *f g*, which in the example finishes the scroll. Set off from *g* to *h*,

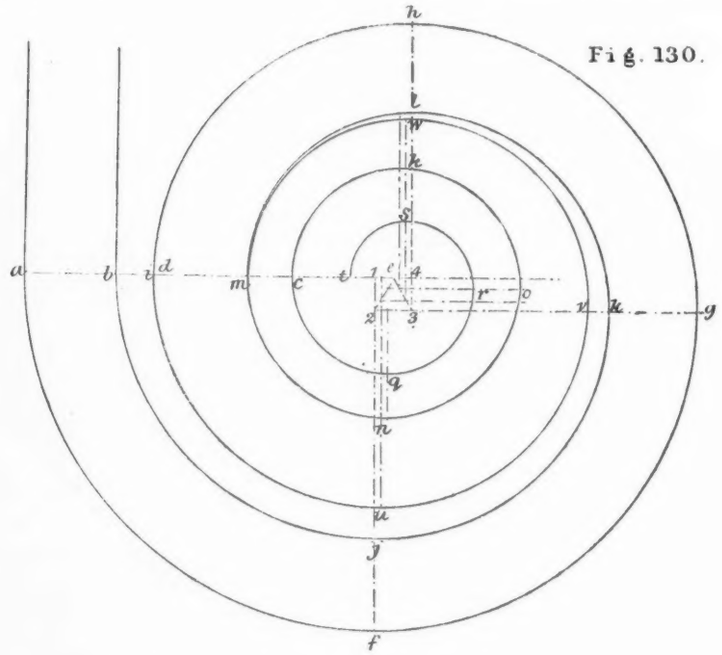


Fig. 130.

and from centre 5 describe the arc *h i*, from 4 the arc *i j*, and from 3 the arc *j k*.

(*c.*) *To describe the spiral in fig.* 130.—Let *a b* be the breadth of rail. Set off this four times on the line *a e* to *e*. Divide the distance between *a* and *c* into two equal parts in the point *d*. Divide *d a* or *d c* into equal parts, one more than the number of revolutions the scroll is designed to be—in the example this is three, so divide the parts *d c* into four equal parts; take half of one of these parts and set it off from the point *e* (see also fig. 131, which is the eye of the scroll on a larger scale), on either side to the point 1 and 4; draw *e f*, 1 2, and 4 3 parallel to each other, and make 2 3 equal to 1 4, thus completing the square. Join *e* 2, *e* 3, and divide *e* 2 or *e* 3 into the same number of equal parts as there are to be revolutions in the scroll, as three in the points 10, 6—11—7. Join 6, 7—10, 11, by lines parallel to 2 3, and 6, 5—7, 8—10, 9, and 11, 12, by lines parallel to *e f*, thus completing the internal squares. The corners of these taken and numbered in succession commencing from the point 1, will be the centres from which the quadrants of circles forming the curve of the scroll in fig. 130 are described;

Fig. 132

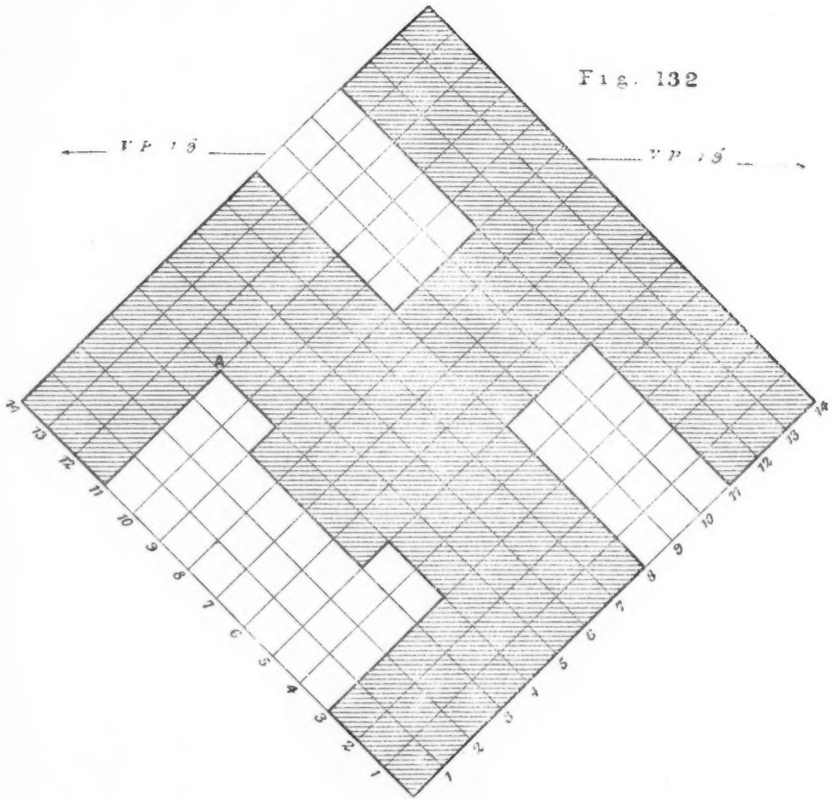


Fig. 133.

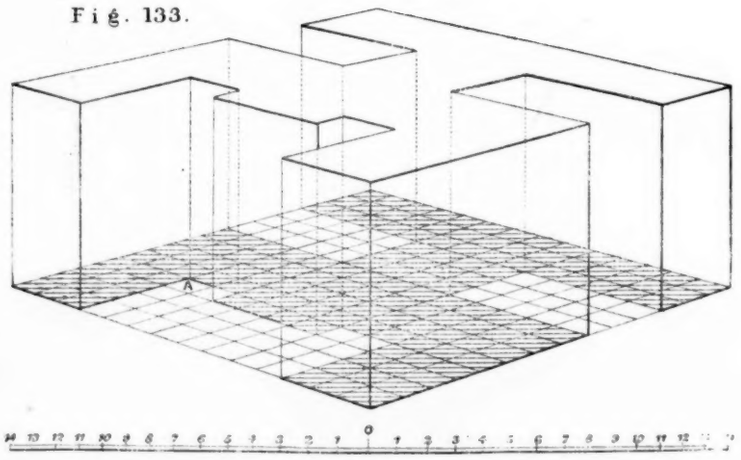
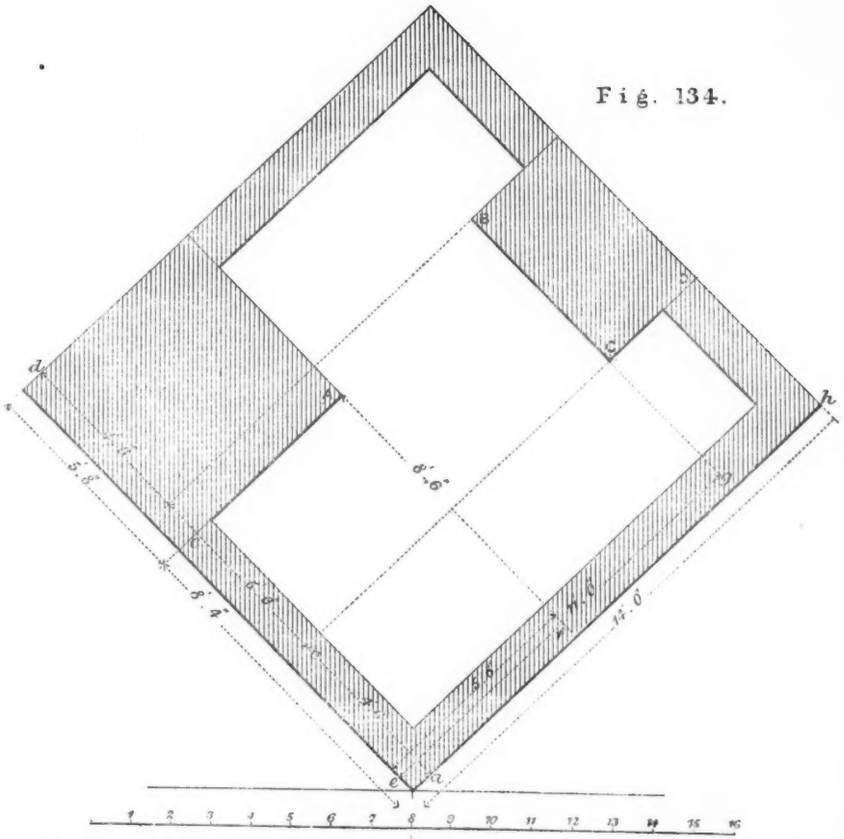
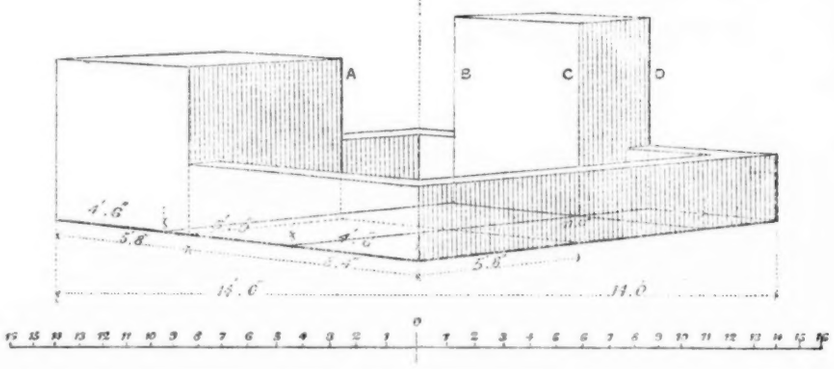


Fig. 134.



Vanishing Point 1.9 to left.

Vanishing Point 1.9 to right.



the operations being as follows:—the numbers of the centres being taken from fig. 131, the "eye" in fig. 130 being too small to admit of the various numbers being given in the drawing. From the centre 1, fig. 130, draw a line 1 *f*, at right angles to *a c*, and from 1, as a centre, with radius 1 *a* describe the arc *a f*, cutting 1 *f* from 2, parallel to *a* and *c*, draw 2 *g*, and from the point 2, as centre, with distance 2 *b* describe the arc *f g*, cutting 2 *g* in *g*. Parallel to 2 *f*, from the point 3 draw a line 3 *h*, and from

Fig. 131.

3 as centre, with radius 3 *g*, describe the arc *g h*. From the point 4 as centre, with radius 4 *h*, describe the arc *h i*. From 5 (see fig. 131), draw 5 *n* parallel to 2 *f*, and from 5 with 5 *i* as radius describe the arc *i u*. From 6, as centre, with 6 *u* as radius, describe the arc *u v*. From 7, with 7 *v*, describe the arc *v w*. From 8, with 8 *s*, describe the arc *k c*. From 8, with 8 *w*, describe the arc *w m*. From 9, draw a line 9 *n*, parallel to 2 *f*, and from 9 with radius 9 *m*, describe the arc *m n*. From 10, draw a line 10 *o*; and from 10 with 10 *n*, describe the curve *n o*. From 11, draw a line 11 *k*, parallel to 2 *f*, and from 11, with 11 *o*, describe the arc *o k*. From 12, with 12 *k*, describe *k c*. The arc *c q* is described from 9; the arc *q r* from point 10; the arc *r s* from point 11; and arc *s t* from 12. From centre 1, with 1 2 as radius, describe the arc *b j*, from centre 2, with 2 *j*, the arc *j k*, from centre 3 the arc *k l*, and from centre 4, the short arc running into *w m*.

(36.) **Method of Delineating Architectural Subjects in Perspective, to which the usual Scale of Equal Parts are Applicable, in Reading the Dimensions.**—In continuation of our description of this method as given in note No. 28, p. 189, we here illustrate a "Block Plan" in fig. 132, which is drawn to a scale of ¼ inch to the foot. This is divided into a series of squares, each representing a foot superficial. In fig. 133, we give the same plan in perspective, by the "diminishing scale" (see note No. 28, p. 189). This illustration is given here to show how any point in a plan as A, or an internal angle can be obtained. To find the point C A, measure off base line eleven feet to left of "line of height" (see note No. 28, p. 189), and four feet to right of same. From these two points draw lines to the "vanishing points," which are placed right and left at a distance of one foot nine inches, the point where these two lines intersect, gives the point A; and in like manner all the other points can be obtained. If, however, the plan be divided into squares, as in fig. 132, the intersecting points of the squares —and each being as above noted a foot in dimension—can be at once obtained by an inspection of the plan. Fig. 134 is designed to show the method of finding the position of any points as B C D, which do not lie on, or come up to the face line of the outside walls, as do the points in fig. 131. These points are bound by intersection of lines dating from dimensions measured off upon the base lines *e d*, *a h*, fig. 134, set off from the point *a* to *b*, a distance, taken from the scale, of four feet six inches, and from *b* to *c*, a distance of five feet, these being on the left hand base line *a d*. On the right hand base line, set off from *e* to *b*, a distance of five feet eight inches, and from *e* to *g*, a distance of eleven feet. From these points draw to the corresponding "vanishing points" as the left hand base line points to the left hand vanishing point, and the intersections of these lines will give the points of the internal angles A B C D, the point A can be obtained in the same manner. Fig. 135 gives to left hand of centre line *a b*, half of the plan of a cottage with dimensions of doors and windows marked—the half plan shows also plan of roof with intersecting point A of ridge. Half of the elevation is given to the right hand of centre line *a b*, this is drawn to a scale of ⅛ inch to the foot. In fig. 136, we give a perspective drawing of the same cottage with scale attached; and with the converging lines drawn partly in from same, thus showing at a glance the method of measuring and putting in angles. The method of finding the ridge point A by intersecting lines, is also shown in the diagram, six feet being set off to the left of the line *a*, and thirteen feet to the right of same line, and thus showing the intersecting lines as dotted. Further illustrations of this method will be given in a future note.

(37.) **The Delineation of Mechanical Subjects.**—(1) *The Screw.*—In note No. 27, p. 189, we gave the methods of delineating curves, the outlines of which are formed of eccentric curves. We now take up the subject of screws, as forming the basis of a useful lesson or two in mechanical drawing. The first illustration is that of a square-threaded screw, as in fig. 137. Let *a b c* be a circle, the diameter of which is equal to that of the outside of the screw. Through the centre *e* draw a line *e f*, and on this, at any convenient point above the circle the line, *g h*. Draw the diameter *b a*, and from centre *e* describe a circle concentric to the larger circle, the diameter of circle *i j* being equal to the diameter of the inside of screw. From the points *b j*, *a* and *i*, draw, parallel to *e f*, the lines *a k*, *i l*, *j m*, and *b n*—these will give the boundary lines in the elevation of the outside and inside of the screw, the distance, as *b j* or *a i*, being equal to the depth or projection of the screw from the central bar or body of the screw round which the thread is cut. With the distance *a i* or *b j* set off in the line *e f*, from point *o*, a series of distances, as *o p*, *q r*, *s t*, *u* and *v*, and through these draw lines parallel to *g h*, as *w p x*—*y q z*—*a' r b'*—*c' t d'*. The parts, as that between *g h z b' q w*, give the space of one complete thread, the sides of which are bounded by right lines, as *g w*, *z b'*, these points being joined by curved lines, as *g e' f' g' p j' i' h' z*, which are found by the following operation. Divide the semi-circle *a c b* into any number of equal parts, as eight in the diagram. From these points draw, parallel to *e f*, lines as in the diagram, as 2 *f*, 3 *m*, &c. Divide the distances *g w x z*, each into four equal parts, and through the points, as 1′ 2′ 3′, draw lines parallel to *g h*, as 1′ 1′, 2′ 2′, 3′ 3′. The intersection of the line 1—drawn from semi-circle *a c b*—with the line 1′ 1′ on the line *g w* will give a point *e'*; the line 2, with 2′ 2′, a point *f'*; the line 3, with 3′ 3′, a point *g'*. The intersection of the line 7, from the semi-circle *a b c*, with the line 3′ 3′ on *x z*, will give a point *h'*. The intersections of the lines 6 and 5 with lines 2′ 2′, 1′ 1′, will give points *i'* and *j'*. Through the points *e' f' g'*, *p j' i' h'*, draw, by hand, a curved line, terminating at *g* and *z*. Divide the distances *w y*, *z b'*, each into four equal parts, and through the points draw lines parallel to *g h* as before. The intersections of these with the vertical lines drawn from the points 1, 2, 3, 4, 5, 6, and 7 on the semi-circle *a b c* will give a series of points, as *k' l' m' n' o'* and *p'*, through which a curve is to be drawn by hand, terminating at the points *w* and *b'*. The boundary lines of upper and lower edges of the first thread are thus put in. The same operation repeated will give the lines of the second thread, *y a' d' d''*, and of the third, *c' c'* and *q' q'*. By examining fig. 137 the student will perceive that the ends of the threads are joined with curved lines, as A A to the central part B B B. These go downwards to the left hand, and upwards to the right of the screw, as will be seen by inspecting fig. 137. These curved parts are put exactly in the same way as the other curves, being drawn through points obtained by the intersection of the horizontal lines as 3′ 3′ or *w y*, 1 2, &c. in the semi-circle *a b c*. Thus the curve A between the points *y* and *w* is drawn through the points *r' l'* and *s'*, but the full line stops at the vertical line *u' t'*, the boundary line of the central bar or core of the screw. The curve A between the points *b'* and *d''* is drawn through the points given by the intersection of the lines at *v' w'* and *x*, but stops also in full line at *y' z'*, the side of the central core. We have continued these curves in dotted lines, as also those from the points *z' b'* and *d'' d''*, in order to show how the thread winds round the central core or bar B B. But it will be observed that the under parts of the thread join the central core or bar by means of curved lines, as C C in figs. 137 and 138, those curves being below the thread in the left-hand side of the screw, and above it to the right hand. These curves are obtained by the intersection of the horizontal lines, as 1′ 2′ 3′ on *g w*, with those vertical ones drawn from points found on the *inner* semi-circle *i i j*. This semi-circle is divided into the same number of equal parts as the semi-circle *a b c* (the division in *i i j* will be most readily found by drawing from the centre *e*, radial lines, as *e i*, these will cut *s i i j* in the required points as 1″, &c.) Lines are drawn from the points on *i i j*, as 1″ 2″ 3″, &c., and these intersecting with the lines on *y w*, as 1′ 2′, give points *z'* 1^3 2^3, through which the curve is drawn by hand. In like manner the reverse and corresponding curve *z' q* is put in by drawing a curved line through the points C, 3^3 and 4^3, these points being found by the intersection of the lines 7″ 6″ with the lines 3′ 2′ on the line *b' z*. It will be observed that these curves all start from the lines at *a' b'*, *g h*, as at *z'* and 5^3. The student should study the diagram carefully before beginning to draw it, which he should do on a larger scale even than that given, so as to have a thorough knowledge of the relations which one part bears to another. We might have shaded fig. 137; but as this would have much obscured the several lines and points, we prefer to give one-half of the figure shaded in fig. 138, which will help the pupil to an intelligent comprehension of the various parts of fig. 137.

Fig. 135

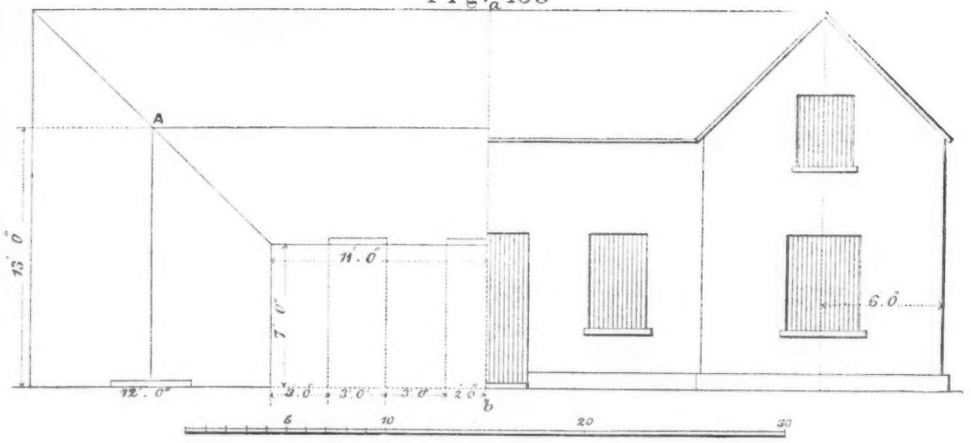
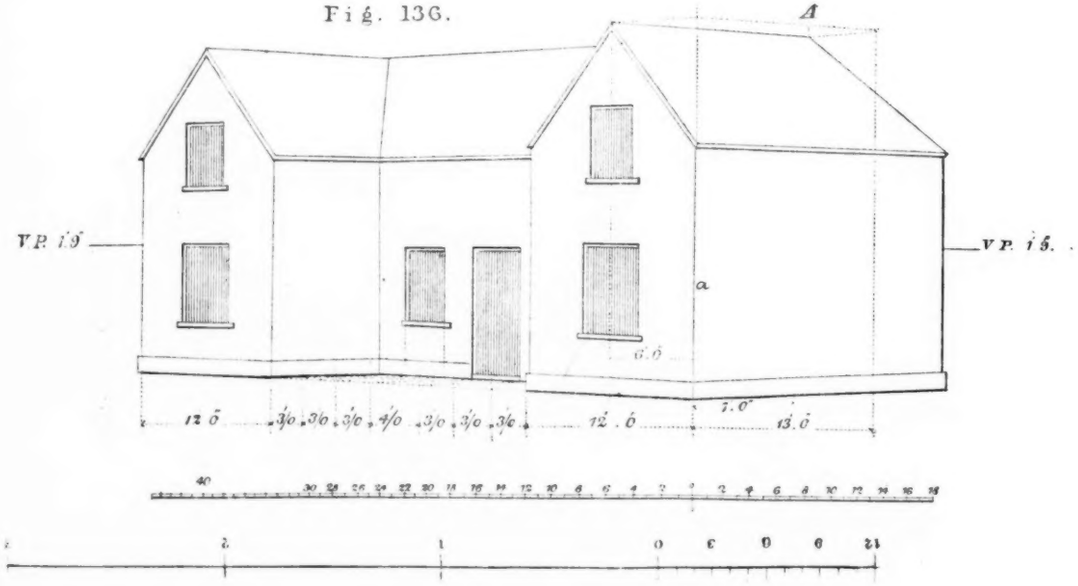


Fig. 136.



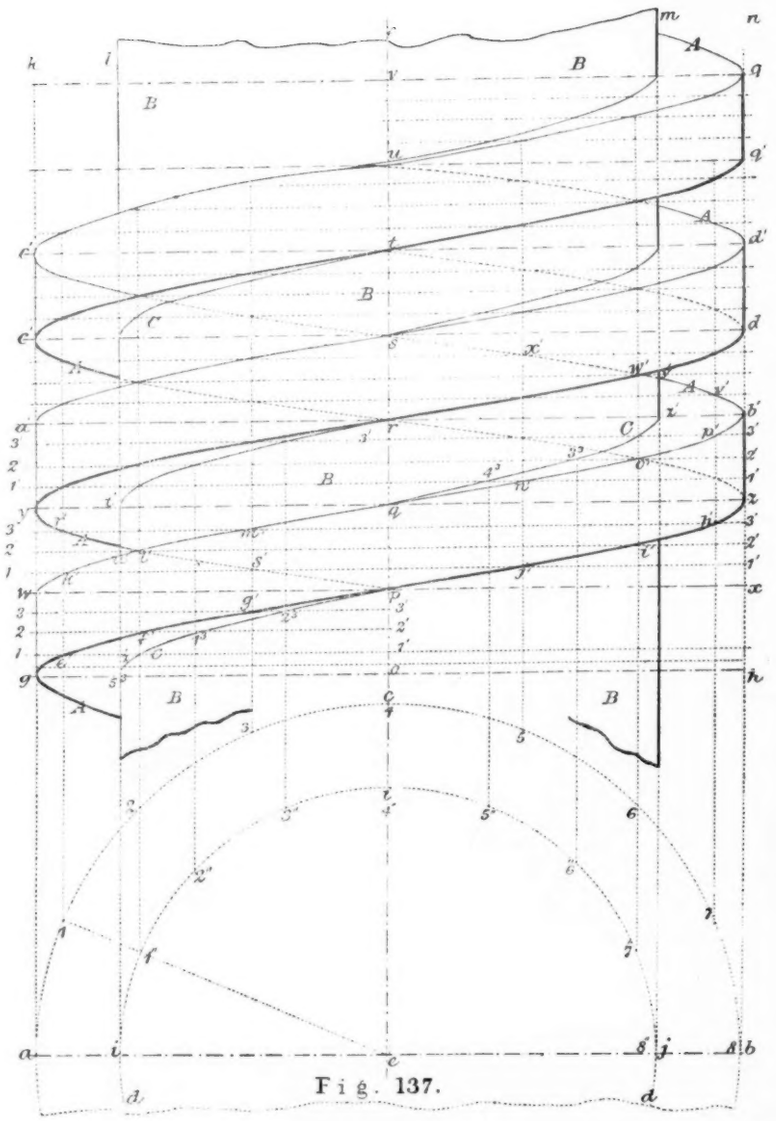


Fig. 137.

(38.) **The Student's Sketch-Book of Working Drawings.**—Under the above heading we propose to give from time to time drawings of various subjects connected with what may be called by the general term of the "Constructive Arts," embracing, as the title to our Note indicates, those which are engineering and mechanical as well as architectural. The first section (A) will comprise examples of details of steam-engines, tools, and their mechanical movements, and of subjects which come more particularly under the head of mechanical construction. Under the second (B) will come subjects such as bridges, harbour work, details of hydraulic and sinking work, and what may be generally called the civil engineering subjects. Under the third section (C) will be embraced examples of various architectural structure, and building details. The drawings, in addition to being drawn to scale and with dimensions figured, will be as a rule so

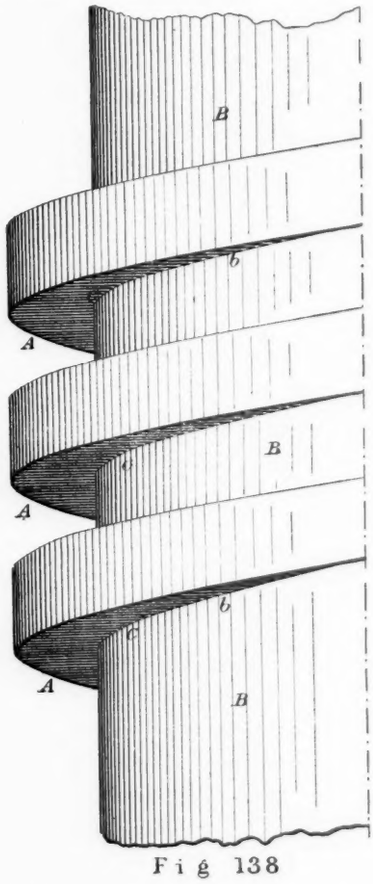


Fig 138

arranged and prepared as that they will serve as lessons to the student in mechanical engineering and architectural drawing. The first example we give comes under the section A, Mechanical—being drawings of the piston of a steam-engine of six-horse power, drawn to a scale of one-sixth full size, or two inches to the foot. Fig. 139 is the plan of piston cover, showing the appearance when looked down upon; the open circular part *a a* passes over the projecting part *b b*, fig. 143, and the cover in fig. 139 is secured to the body of the piston in fig. 142 by the bolts *b b b b*, fig. 139, passing into the bolt holes *c c c*, fig. 143. Fig. 140 is section of fig. 139 through the line *c c*, fig. 141 being an elevation. In fig. 140 the bolt *a* corresponds to the bolt *b'* in fig. 139; fig. 143 is section in the line *a b*, fig. 142. In place of making the body *e e*, fig. 143, of the piston a solid circular part, it is to give lightness formed as shown in plan, fig. 142, with projecting parts *c c* for the bolt holes, and depressions as *d d*. The end of the piston-rod (given with other and attached details in a succeeding note) is passed into the aperture *a a*, fig. 143, and secured by a key passing through the key-slot *d*. When the cover in fig. 139 is put on the body of the piston in fig. 142, spaces *f f*, fig. 143 would be left. Those are filled up, however, by "expanding rings," two in number, shown in figs. 144 and 148, placed one above another, the lower ring resting upon the ledge *g g* of the piston body, fig. 143. The rings are so placed with relation to each other that the narrow point *a* of the upper ring, fig. 148, is covered by the broad part *a* of the lower ring, fig. 144. The rings are made of brass, but do not meet at the ends; a space cut in a diagonal form, as *a* in fig. 150, being left between them. The ends are secured together by bolts and nuts, *b c*. "Saw-draughts," as *d d d*, figs. 144 and 148, are made in the inside of the rings; that is, parts are cut out for a certain depth in the ring; these allow of the ends being brought together, and give a certain degree of expansibility to the rings, so that as they wear by working in the cylinder they can be allowed to spread out, so to say, or expand and keep steam-tight. There are many forms of pistons, with arrangements for expanding, but this now illustrated is a very efficient one, and perhaps one of the simplest kind. The centre lines will serve to show the pupil how the drawings are to be copied.

Fig. 145 is section of fig. 144 on line *a b*, fig. 146, elevation, Section C, Architecture and Building. (1.) Square jamb and reveal in brickwork for a wall 2¼ bricks thick. In fig. 151 we give first course, in fig. 152 second course of this, in fig. 153

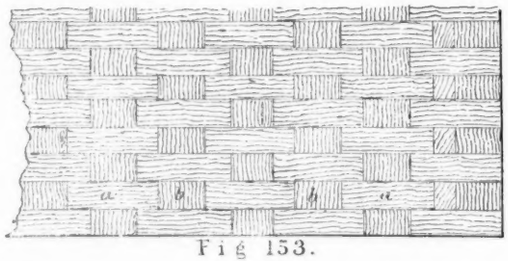


Fig 153.

elevation, and in fig. 154 section in line *c d*, fig. 155, section in line *a b* in figs. 151, 152. The bond here is "Flemish." In fig. 151 *e e* are "closers," *d* is a half closer in fig. 152. The bond in this example is that known as "Flemish," in which each course is made up of a "stretcher," as *a* and a "header," as *b*, alternately (see fig. 153). A "course"

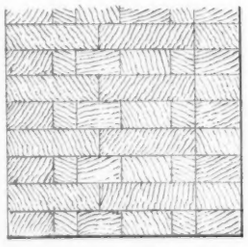


Fig. 154.

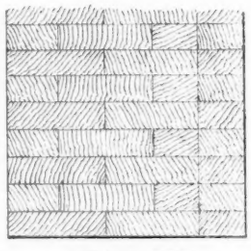


Fig. 155.

is one layer of bricks, and the depth is of course equal to the thickness of a brick. A "stretcher" is a brick the length of which runs in the direction of the length of the wall, as *e e* in fig. 152; a "header," that which runs at right angles to this, or across the wall as *f f*. A "closer" is half a brick cut in the direction of its length, as *e e*, fig. 151, *g g* in fig. 152. A "bat" is half a brick cut across its breadth, as *h h*, figs. 152 and 153. A half closer is shown at *d* in figure 152. Closers and bats are required to make up what is called the "bond," about which on such a special subject of importance technically we shall have somewhat to say in a future Note. Three-quarter bricks are also sometimes required; these are obtained by cutting off one-fourth of the length of a brick, that is, making the cut across its breadth. In fig. 151 the part from *a* to *e* is the "jamb," the part *g* is called the "reveal," in Scotland it is called the "rybat." The reveal is therefore the depth, in the case of a window, measuring from the external face of wall to the front or outside face of the window frame. The diagrams in figs. 151, 152, show a reveal of half a brick only in thickness. Fig. 153 is the elevation, in which the "stretchers" *a a* are indicated by horizontal, the "headers" by vertical lines, the "closers" by cross lines. Fig. 154 gives a vertical section to the height of eight courses, through the line *a b*, fig. 155, through the lines *c d* in figs. 151, 152.

(39.) **The Architectural Mouldings, and how to Describe them.**—Continuing our examples of these, begun in

Fig. 139.

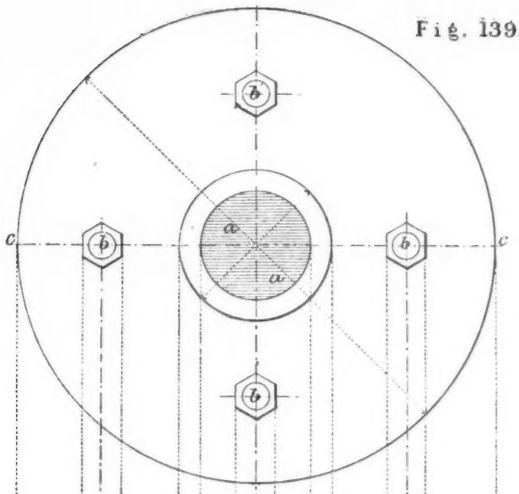


Fig. 140

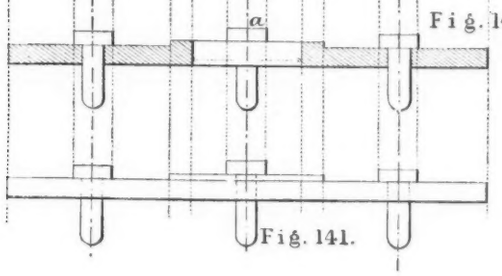


Fig. 141.

Fig. 142.

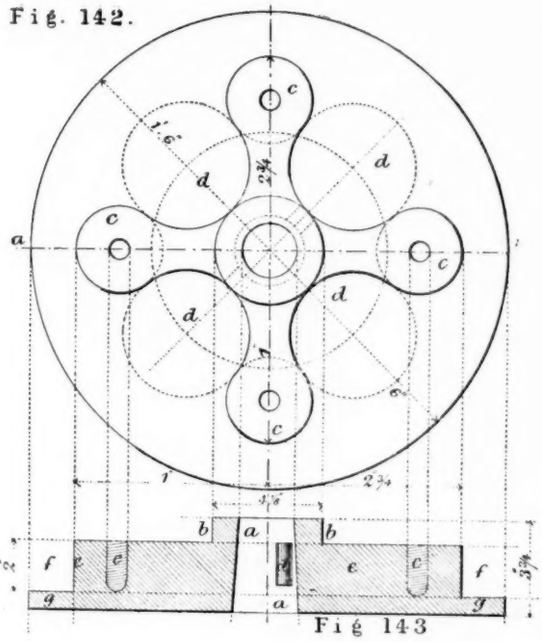


Fig 143

Fig. 144.

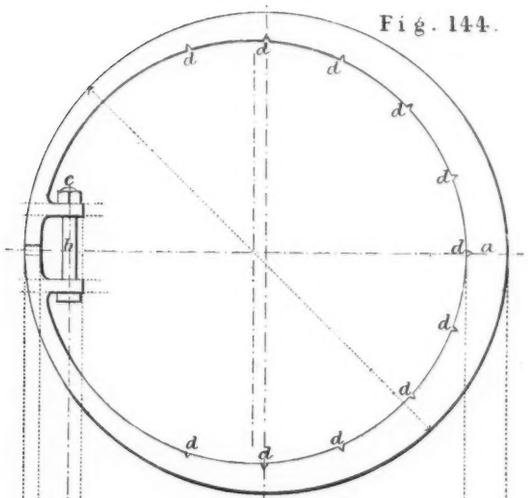


Fig. 145.

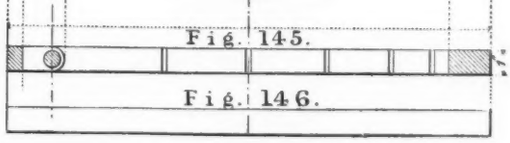


Fig. 146.

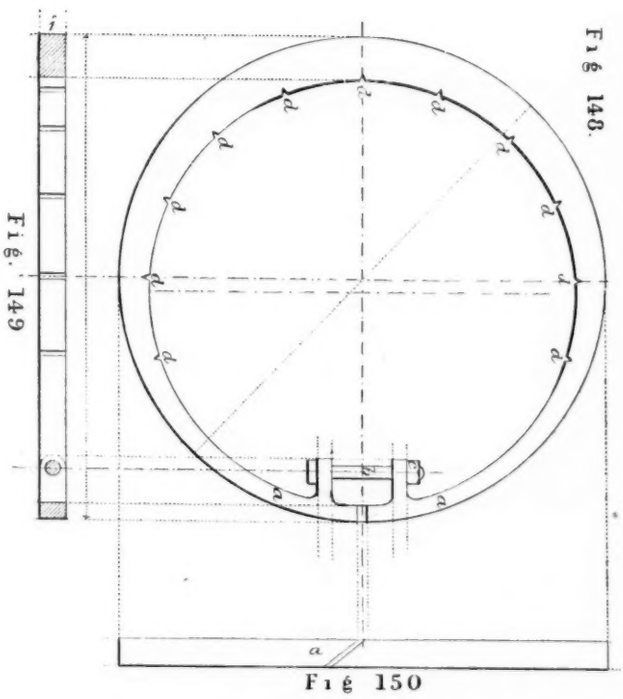


Fig. 149

Fig 150

Fig 148.

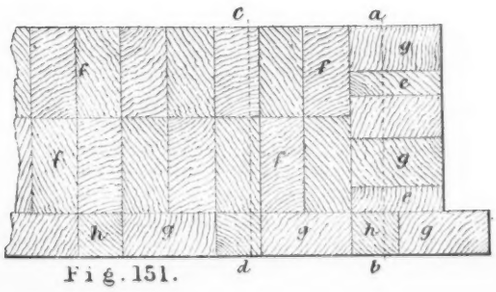
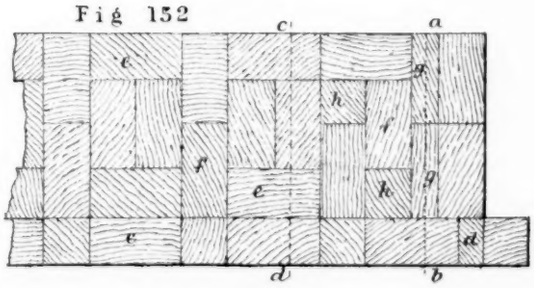


Fig. 151.

Fig 152



Note No. 29, p. 191, we give in fig. 156 a sketch of the moulding known as the "cavetto," or "hollow." In figs. 157, 158, 159, and 160, we illustrate methods of describing this, in the Roman

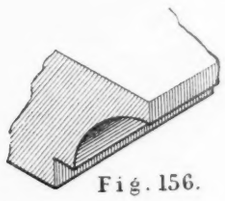


Fig. 156.

style, by means of arcs of circles. In fig. 157 the projection *a b* and the height *b c* are equal, thus making the arc *a c* exactly equal to the quadrant of a circle. Draw from points *a* and *c*,

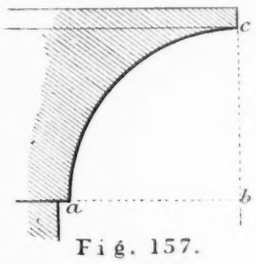


Fig. 157.

terminating the moulding lines at right angles to each other, and intersecting in the point *b*. From *b* as a centre, with *b c b a* as radius, describe the arc *a c*. In fig. 158 the projection *a b* is

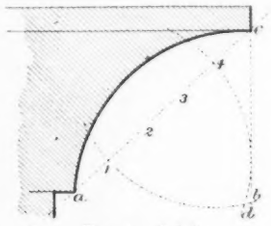


Fig. 158

less than the height *b c*. Join *a c*, and divide it into five equal parts; from the first and fourth of the points on this as centres, with 1 4 as radius, describe arcs, cutting in the point *d*; from *d*

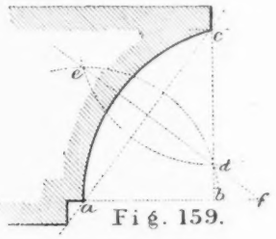


Fig. 159.

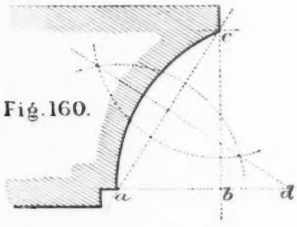


Fig. 160.

as a centre, with *d a* or *d c* as radius, describe the arc *a c*. In fig. 159, the projection *a b* is one three-fourths of the height *b c*. Continue the base line *a* of the moulding to an indefinite distance, as to *f*. Join *a c* from *a* and *c* as centres, with any distance greater than half of *a c*; describe arcs, cutting each other in the points *d e*; through these draw a line, cutting the line *a f* in *f*, from *f* as a centre with *f a* or *f c*, describe the arc *f c*. In fig. 160, the same method of describing the curve is given—the

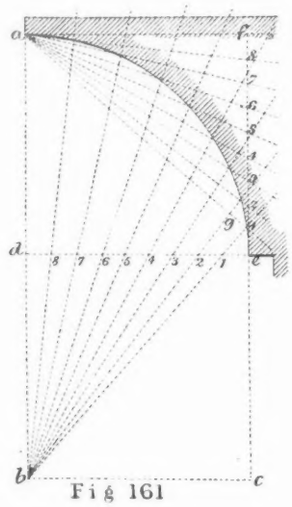
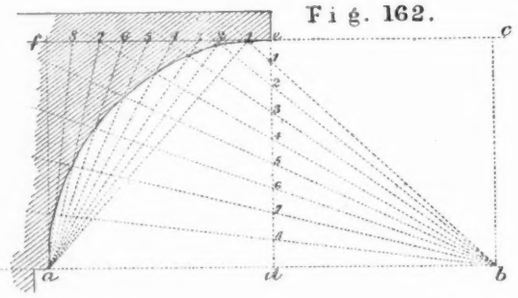


Fig 161

projection *a b* being two-thirds of the height *b c*. In figs. 161 and 162 we illustrate methods of describing the cavetto in the Grecian styles, where the curves are elliptical in section, the heights being in both diagrams equal to the projections. Draw any line *a b*, and at right angles to another, as *b c*. Make *b c* equal to the

Fig. 162.



height or projection of the moulding required; from *c* draw *c f* parallel to *a b*; make *c e* equal to *c b*, and *e f* equal to *c e*; through the points *e* and *f* draw lines, cutting *a b* in *d* and *a*; *d e* is the projection, *e f* height of the moulding. To find the curve *a e* divide *e d*, *e f*, both into the same number of equal parts. From the points on *e d* draw lines to the point *b*, continuing them for some distance in the direction of the line *a f*, and from the points on *e f* draw lines to the point *a*. Number them as in the drawing—the point 1 in *e f* being nearest the point 1 in *e d*. Through the points formed by the intersection of the corresponding lines draw the line by hand. Thus, the intersection of the line *b* 2 with *a* 2 gives the point *g*, and so on.

TINCTURE of Pyrethrum for Toothache.—G. C. Close. (*Proc. Amer. Pharm. Assoc.*, 1871, 489.) The author has found a concentrated alcoholic tincture of pyrethrum to be the best ordinary remedy for Toothache. He thinks it will relieve quite as large a proportion of cases as creosote, and it is far more pleasant to use, not being liable to blister or make ugly sores in the mouth. It may be freely applied to the gums for ulcerated teeth, or in the ordinary way to the cavity where one exists.

APPARATUS FOR SUPPLYING WATER TO CATTLE UPON RAILWAYS.

A PATENT has been taken out for an invention, at once humane and economical, by Mr. W. J. Bonser, of Colebrooke House, Highbury New Park, London. Its object is to supply water to cattle upon railways without removing them from the trucks. The accompanying drawings exhibit the general appearance and show fully the mode of working. The following estimate of the expense has been prepared by Messrs. Ruston, Proctor, and Co., of Lincoln, the engineers to the patentee.

Thirty lengths of apparatus 20 ft. long each, each length consisting of a galvanized iron trough 20 ft. long × 14 in. wide × 12 in. deep; 1 cast-iron standard, 1 plummer block, 1 double stuffing-box, 1 hollow axis 20 ft. long × 2¼ in. inside diam. × ¼ in. thick, 2 cast-iron levers keyed on axis, 2 branch tubes, 2 brass pivots ground and fitted to lever ends to act as stop-cocks, 2 balance weights, waste-pipe and cock, 4 chains with all bolts and nuts necessary for fitting to sleepers, fitted up complete as per drawing, at £28 each £840 0 0

One terminal standard with 1 plummer block, 1 double stuffing-box, 1 stand pipe with main stop-cock, 2 wrought-iron pipes, 2 elbows with necessary bolts and nuts, fitted up complete as per drawing £12 0 0

Simple as it may seem at first sight, this question of affording proper accommodation to cattle in transit is attended by various

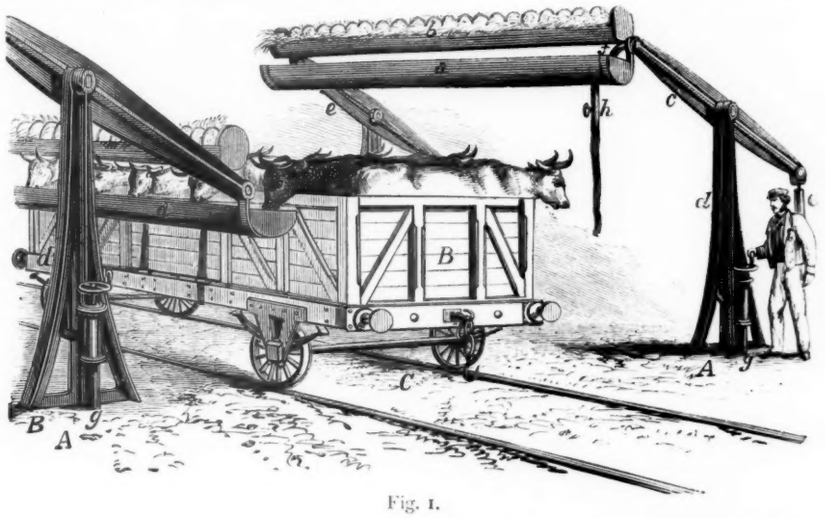


Fig. 1.

difficulties. Various points of railway convenience require to be met, and the first cost of any suitable apparatus is great, especially if applied to each truck according to the plan of some inventors. Mr. Bonser's idea is that on a journey such as that from Aberdeen to London, the erection of his apparatus at distances about two hundred miles apart would suffice for all practical purposes. As one of the largest factors in the Metropolitan Meat Market, he has had ample opportunity for studying the matter in all its bearings.

In addition to the misery caused by the transit as at present conducted, it is testified by experts, in the Report of the Committee of Privy Council, "that every bullock, from the moment it leaves the grazier's yard, will lose eight pounds a day in weight besides loose fat."

Professor Simmonds says: "There cannot be a doubt that the feeding and watering of animals on their journey to a fat cattle market would prevent, to a certain extent, that waste of tissue which invariably takes place in the travelling of cattle, and would also tend to maintain that juicy and well-known superior

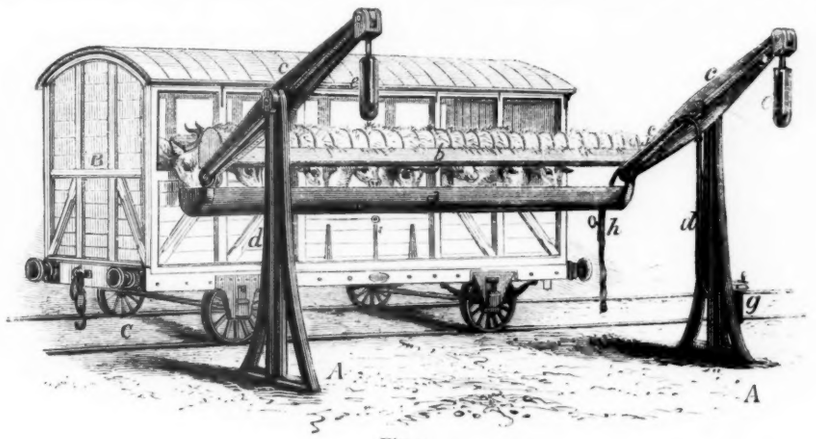


Fig. 2.

quality of the meat which is met with in animals killed at home. From a humane point of view, also, it is exceedingly desirable that animals should have both food and water on long journeys, the latter being especially required during the heat of summer."

We have devoted considerable space to this invention, as one which deserves careful attention on both sides of the Atlantic.

A A represents upright standards supporting on pivots levers *c c*, to one end of which levers is suspended a trough *a*.

This trough when empty is retained in an elevated position by the balance weights *e e*, as represented on the right side of fig. 1.

A truck B containing cattle being brought into the siding alongside the suspended trough, and the supply cock *g* being turned, water will flow through the supply pipe *d* into the trough *a*, which being, when filled, heavier than the balance weights *e e*, will move in the arc of a circle until it assumes a position level

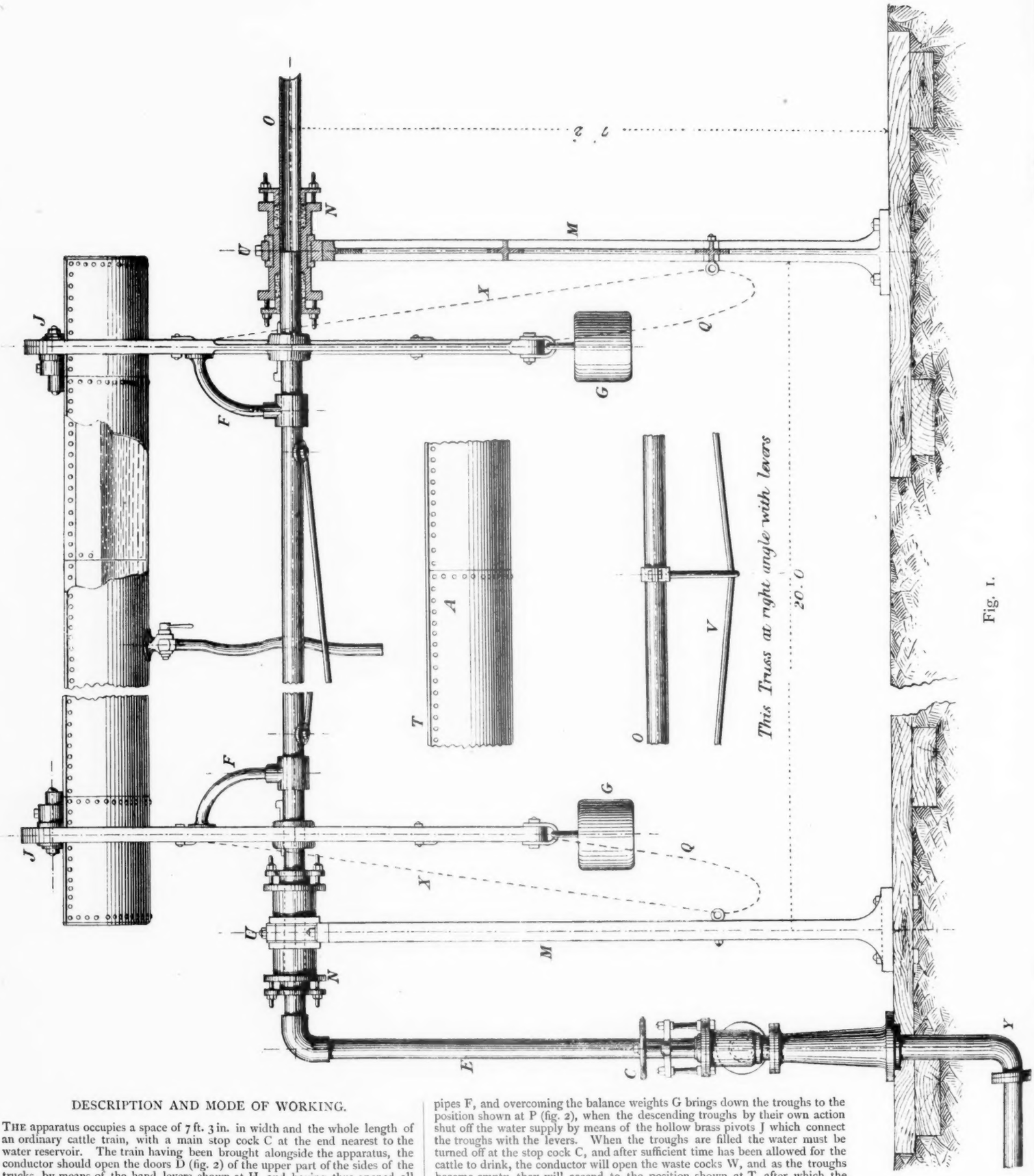


Fig. 1.

DESCRIPTION AND MODE OF WORKING.

THE apparatus occupies a space of 7 ft. 3 in. in width and the whole length of an ordinary cattle train, with a main stop cock C at the end nearest to the water reservoir. The train having been brought alongside the apparatus, the conductor should open the doors D (fig. 2) of the upper part of the sides of the trucks, by means of the hand levers shown at H, and having thus opened all the trucks, he, by means of the cock C, turns on the water, which flowing through the pipe E along the hollow axis O, supplies all the troughs by the pipes F, and overcoming the balance weights G brings down the troughs to the position shown at P (fig. 2), when the descending troughs by their own action shut off the water supply by means of the hollow brass pivots J which connect the troughs with the levers. When the troughs are filled the water must be turned off at the stop cock C, and after sufficient time has been allowed for the cattle to drink, the conductor will open the waste cocks W, and as the troughs become empty, they will ascend to the position shown at T, after which the conductor lets down the truck doors D by the lever H, and secures them by means of the long link shown at L. The train may then proceed without delay.

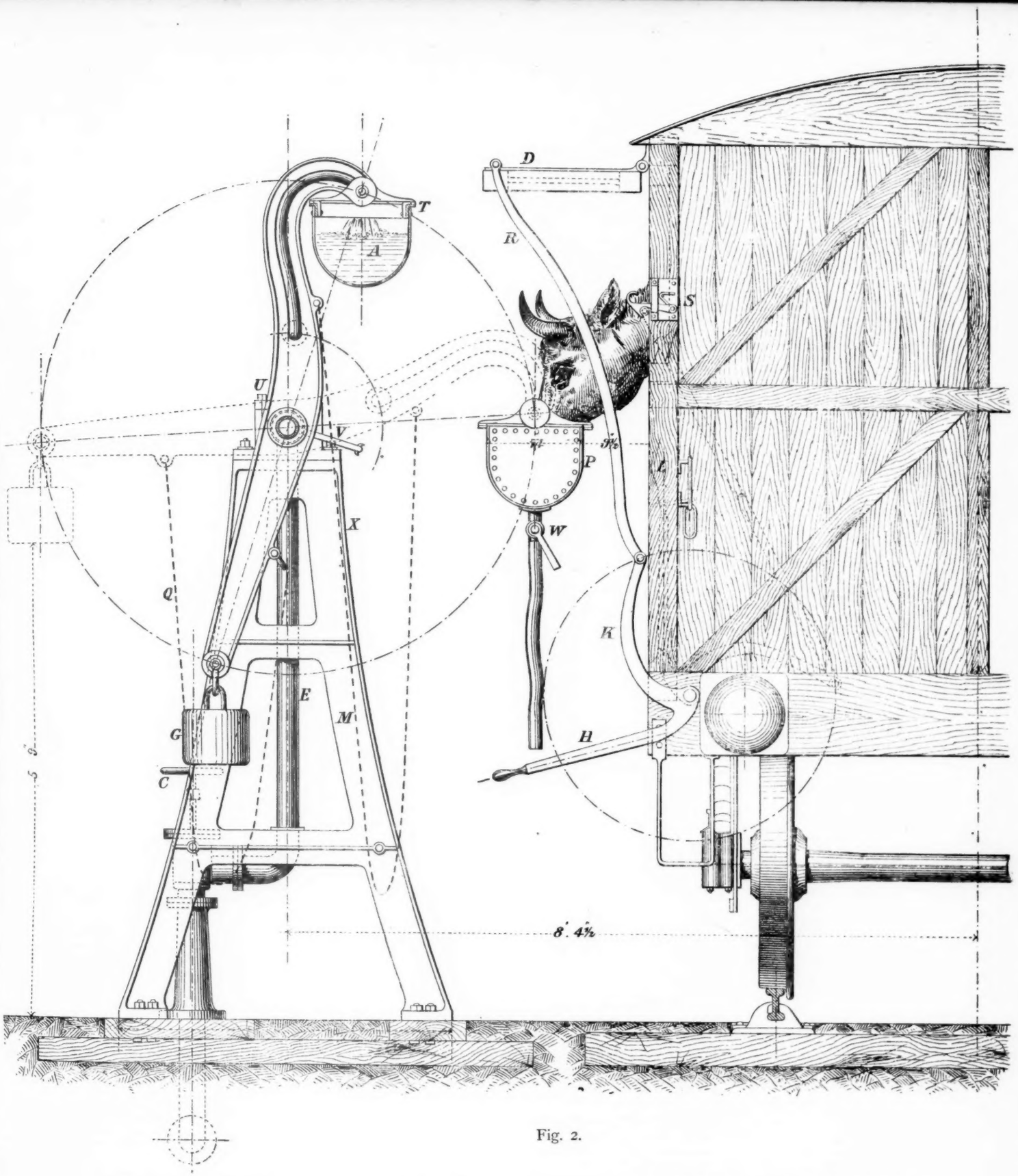


Fig. 2.

The truck doors may be further secured by spring catches as shown at S (fig. 2) one at each end of the truck and self-acting. The lever H is fixed on a spindle which passes through the truck bottom, and having on each end a lever K jointed to a rod R by which the door is raised.

X is a chain attached to each lever to prevent the ascent of the trough as the cattle consume the water.

M M are cast-iron standards bolted down to wood sleepers.

N N are double stuffing boxes, in which the hollow axis O revolves, making a tight joint between the different lengths—themselves being free to revolve in a plummer block U.

A represents the drinking trough, made of strong galvanized iron, riveted to round edged angle iron at sides, and $\frac{1}{4}$ in. boiler plate at ends. The trough is 14 in. wide and 12 in. deep.

V is a truss rod to prevent deflection in the hollow axis when the trough is down and filled with water.

Y is the main water pipe from reservoir.

The main hollow axis O is a strong wrought-iron tube, $2\frac{1}{2}$ in. diameter inside, the ends of which are turned and polished.

The pipes F are wrought-iron 1 in. diameter inside.

with and close to the opening in the truck B, through which the cattle can thrust their heads to drink, as shown in the left side of fig. 1. The lever *c* being connected with the supply cock *g*, when the trough descends the supply of water will be stopped or regulated to keep the trough supplied as the water is consumed by the cattle.

After sufficient time has been allowed for the cattle to drink, by turning the cock *h* the water will escape through the waste-pipe, and the trough, again becoming lighter than the balance weights, will ascend and resume its former position, clear of the truck, and the train can proceed without delay.

Above the trough *a* may be fixed a rack *b*, to be filled with hay previous to the arrival of the train. When the cattle have had sufficient water, by the moving of a lever the trough will be allowed to descend sufficiently to bring the hay rack level with the opening in the truck, and upon allowing the water to escape, the rack and trough will together ascend clear of the truck.

Fig. 2 represents the same arrangements applied to a covered cattle truck.

By the employment of a sufficient number of these troughs, and their connection with a main pipe, any number of trucks in a train may be simultaneously supplied by the turning of a single cock.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A REGULAR meeting of this society was held at its rooms in New York, Wednesday evening, Dec. 18th.

"A Record of some Experiments, showing the Character and Position of Neutral Axes, as seen by Polarized Light," by Louis Nickerson, C.E., of St. Louis, Mo., was presented and discussed.

During the researches of Eaton Hodgkinson, published in 1842, he took the ground that the neutral axis in a beam shifted as the load was increased, and finally took position where the compressive strength of the material above it would be equal to the tensile strength of that below it.

He fixed this for a cast-iron rectangular beam about to break at one-seventh its depth from the top, because its resistance to tension was one-seventh that to compression, and this was apparently proved by an inspection of the fracture of beams which were broken. In 1855 Henry Barlow made experiments to test this theory, in the course of which he claims to have established that the neutral axis of a rectangular beam always lies through the centre of gravity of the section, and recognizes, in addition to the tensile and compressive elements of strength in a beam, a third, due to the lateral adhesion of the fibres, and increasing with the deflection.

Each takes the transverse strength of a cast-iron beam as about 2¼ times as great as it should be, according to its tensile and compressive strength, and records a theory in regard to the character and position of the neutral axis differing from the other.

The experiments here recorded were made to reconcile the results obtained by Messrs. Hodgkinson and Barlow, and to discover whether the "lamination of material in planes normal to the direction of the pressure excited upon it" was due to a periodic action of force, or consequent upon tangential stress, imperfect cohesion of the material, or the running together of internal cells. Polarised light was sent through plates of glass under compression, either as beams or columns.

The difference in the effects caused by similar strains on two materials is relative; and that produced by a force upon glass is like that upon other substances.

The results sought for are from certain general laws of the doctrine of forces, which must be the same for all materials,—and modified, not changed, by any particular one. The transparency of glass and its bi-refractive quality when strained exhibits them to the eye.

In the experiments, structural differences were ignored. Glass, cast-iron and steel are amorphous bodies, yet composed of segregated crystals, and under pressure exhibit a similar characteristic fracture. There is also a like ratio between their compressive and tensile strength, that of glass appearing to be a mean of the other two.

The apparatus used was the one common for experiments with polarized light: a polarizer of glass plates, an analyzer of one plate blackened at the back, and a small brass clamp, with thumb-screw to compress the pieces of glass experimented upon, either as beams or columns.

These pieces, before pressure is applied, appear black in polarized light, glass in an unstrained or neutral state being impervious to it.

A slip, representing a beam, placed in the clamp and the screw slightly tightened, shows at the top and bottom a clear space enclosing a dark space; between which, under greater pressure, it takes sharper outlines; and coloured curves, distinct and separate, appear, following the lines of strain. These increase in number and brilliancy with the pressure, and always move towards the dark and neutral space.

The experiments were made in consecutive steps, the application of force ranging from proportionately a very small tensile with a very large compressive strain, to that where the two were nearly alike, and were described at length.

Coloured drawings representing the effects of polarized light upon the various slips of glass experimented with were exhibited.

The results obtained show that the neutral axis is a flexible line or plane truly parallel to the top and bottom sides of the rectangular beam, and passing through the centres of gravity of its sections *only* when the load is evenly distributed from end to end, or when the beam is infinitely long; and that when there is a local pressure, the neutral axis is more or less governed in its direction and form by the strain passing from the point of local pressure towards the points of support.

The beams of Mr. Hodgkinson were broken at the centre by a blow, in which the neutral axis was located above the centre of gravity of the transverse section. From these experiments it is deduced that this position is due to the application of the force, and not to the ratio of the tensile to compressive resistance.

In comparison with Mr. Hodgkinson's, Mr. Barlow's beams were, in proportion of length to depth, half longer; and he naturally found the neutral axis more nearly horizontal and less distorted.

Glass beams, in length fourteen times the depth, show the neutral axis so nearly horizontal, that he may have overlooked the variation; and it must be almost imperceptible in beams more in length than ten times the depth.

It is claimed that the neutral axis, as exhibited by polarized light, from the cohesion of material or other cause is extended to a breadth, and cannot become a true line, until, in reference to the cohesion, the tensile and compressive forces are infinite. Also that its longitudinal direction, like the directions of lines of strain, is not an arbitrary one, but resultant from the relative qualities and quantities of all the forces in the beam—its evident place in physics being that of still water between opposing eddies or vortices.

The pulsations of completely polarized light are confined to two directions—at right angles to each other.

In the drawings are represented two images of the same object, corresponding to these two directions—one being taken, and the analyzer revolved 90° for the other; they, for convenience termed positive and negative images, are pictures of strains in the beam or column normal to each other. In the first tubular bridges a wave of "buckling" always followed a line 45° from the top where the load was placed, even crossing the stiffening plates. Such strains may be called "strut strains," and their resultant in a beam is vertical. The principal strains in an ordinary beam are horizontal or "flange strains"—being tension in the bottom and compression in the top. Their resultant is also horizontal and normal to the first.

The drawings show that when the "strut" or "flange" strains increase, correspondingly the negative or positive images, as the case may be, grow brighter.

Many strains may exist in the same beam, crossing and there neutralizing each other, and yet elsewhere be individual and intact.

As glass is pervious to polarized light when strained, and impervious when unstrained, the light parts must be strained in proportion to their brightness, and the dark unstrained or neutral, as bi-refraction is caused by strain, both must be governed by the same laws. Further, the resultant angles of the strains and those of polarization are rectangles, and as the strains change in character so do the polar images change in correspondence; therefore the images are pictures of the strains.

Any space which is under no strain, whatever load is applied to the beam, must remain dark under all revolutions of the analyzer; each marks the crossing of the two resultant axes, that of the "strut" and of the "flange" strains.

The appearance of light around the neutral band is the first symptom of distortion in the positive image. Soon faint segments of yellow appear at the bottom, occupying a large part of the space between the supports, and at the top varying with the application of the load.

As the pressure is increased, the yellow from both edges moves

forward towards the neutral band, becomes a zone, and a segment of red succeeds. Both continue to move until the red becomes a zone, and is followed by a segment of blue, between which and the red there is a dark neutral line.

A second similar series may be brought out before fracture.

Mr. Barlow established the existence of a third and important element of strength in a beam, which increases as the beam is bent. The moment of this, or bending resistance, is equal to that of the applied force or bending stress, and their common line moves towards the primary neutral axes as the load is increased; this is shown by the dark lines described.

There are then neutral axes existent, amidst disturbing forces, of a beam which, under increasing loads, shortens in the top and lengthens in the bottom.

A transparent column under pressure exhibits a series of coloured rings—glass showing from three to six at each end, and a softer material, as copal, wreaths of coloured bands from top to bottom, a dark space always occurring between the blue and red, which marks an unstrained part of the column, or a union of equal and opposite forces.

To determine what these dark rings indicated, tests were made upon columns which changed in form under pressure. These were brass tubes $\frac{45}{100}''$ exterior, $\frac{35}{100}''$ interior diameter, and about $1\frac{1}{4}''$ long.

Submitted to compression until they assumed a permanent form, they all exhibited from end to end a series of extended rings uniformly separated, or periodic waves. Other steel tubes also compressed were examined, and an empiric expression derived which will locate any wave in relation to another, the tube being homogeneous.

Hollow columns, if sufficiently under stress, within elastic limits, may be greatly strengthened by bands placed where these waves would otherwise occur. It is inferred that one-third additional material will thus double the strength of the column. In conclusion, the law of periodicity of force in compression, and probably in tension, seems to be proved, and the law of lamination under pressure accounted for.

Discussion.

Mr. Macdonald.—"The experiments upon which formulæ in common use, for the proportion and strength of beams, are based, were made upon cubes of the materials tested, and it is found that the constants derived are inapplicable to ordinary cases in practice."

Mr. Boller.—"A recent comparison of various standard formulæ for the strength of beams, made by taking a given beam and calculating, with each formula, its safe load, gave as follows: two 25 tons, one 30 tons, and one 37 tons. The last was from Mr. Baker's formula, in which he has introduced the resistance due to flexion; the beam taken was $3'' \times 6''$ and 5 feet long. Engineers should know more of the strength of materials. The formulæ used involve the application of constants ranging variously from maximum to minimum strength; these often differ widely, and therefore give uncertain results."

Mr. Macdonald.—"It is known that a beam loaded so that its outer fibres, by formula, should be under a maximum strain, will stand a greater load. The constants employed in calculating the strength of a beam should be determined from experiments upon a similar beam of the same material, and not those given for direct tension and compression."

Professor De Volson Wood.—"The point of greatest interest to him in the paper read is whether the neutral axis is a line or a space, as water in an eddy. In regard to the neutral axis and strength of beams as determined by ordinary rules, the fact is, if we assume in a bent beam that the extensions and compressions are proportional to the distance of the elements from the neutral axis, and take the modulus of tenacity or of crushing, as the case may be, for the modulus of rupture of the beam, a beam proportioned in accordance therewith will have an excess of strength.

"Thus, take a rectangular cast-iron beam, as the best example in practice. According to theory, the mean value of the modulus of rupture should be 16,000 lbs., but it is seen by experiment to be 36,000 lbs.

"Former writers do not explain this discrepancy, but simply admit a defect in the theory."

Mr. Barlow detected a new element of strength, which he called "resistance to flexure," a term which is unfortunate, as all the forces in a beam which resist bending are resistances to flexure. "Longitudinal shearing resistance" is a better term, and one now used.

This force is the resistance of the fibres to being drawn over each other. If there was no such resistance the fibres would not retain their original length.

He found, by a critical examination of iron beams, that the transverse sections remained normal to the neutral axis during flexure, thus proving the existence of a force besides that which produces direct elongation and compression.

This is the longitudinal shearing resistance. Mr. Barlow also determined the laws governing it at rupture, and modified the formulæ accordingly. His experiments are the most weighty and valuable of any made upon beams, as far as theory is concerned. His formulæ and constants agree with the actual strength for all sections which he used.

It is evident the ordinary law, that strains vary as their distance from the neutral axis, cannot apply to beams of **I** section; for, that it may apply, there must be at least a continuity between all the elements of the flanges and the web.

Mr. Barlow's formula for this case cannot be correct. In all **I** sections there is a peculiar combination of the strains about the angles where the flanges and web join. Professor Norton, by direct experiment, determined the fact of a transverse shearing resistance in beams, and the laws governing it in those of rectangular section. The deflections due to longitudinal and transverse shearing resistances tend respectively to diminish and increase that defined by Navier's theory.

Simple rules cannot be given applicable to the varied forms of beams in use. Constants deduced from experiment upon solid rectangular beams will doubtless apply to solid beams of all dimensions, but not to others.

Mr. Boller.—"It is best to make a beam proportioned similar to those to be used, break it, and deduce therefrom a constant.

"The formulæ for **I** beams are safer for thin than thick webs—say $\frac{1}{4}''$ web and $4''$ flange."

Professor Wood:—"The experiments of Baron von Webber showed that the web had never been made too thin; where the flange and web are joined there should be a large curve."

Mr. Macdonald.—"In T. C. Clarke's description of the Quincy Bridge there is a statement that 12-inch **I** floor beams, $15\frac{1}{2}$ feet long, suspended in pairs from panel-points about 12 feet apart, and carrying a single track of $4'\ 8\frac{1}{2}''$ gauge, scarcely deflected under a maximum engine load, which caused a strain upon the outer fibres at least equal to 14,000 lbs. per square inch, according to formulæ in general use."

Professor Wood.—"Structures should not be proportioned in reference to the ultimate strength of the parts, but their elastic limits. Some very tenacious irons have a low limit of elasticity, while in other cases—certain grades of steel for instance—elasticity is preserved under a strain equal to one-half the tensile strength."

The secretary presented communications upon Mr. Nickerson's paper from General Barnard, Colonel Merrill, Messrs. McAlpine and Fuertes, reading of which and further discussion were deferred until the meeting to be held February 19th next.

A regular meeting of this society was held at its rooms in New York, January 15th, 1873.

A paper by Casimir Constable, C.E., of New York, "On Retaining Walls; an Attempt to Reconcile Theory with Experiment," illustrated by a model, was read.

A retaining wall is stable when the moment of its weight about the point of rotation exceeds the moment of a certain triangular prism of material back of the wall about the same point—the intersection of the line of rupture of the wall and the resultant thrust of the prism.

Many formulæ and tables for retaining walls are presented for use without a factor of safety, since walls proportioned therewith, well built, and carefully "back filled," have been permanent.

Experiments made on a small scale, in which the theoretic conditions were more nearly fulfilled than in practice, show that such walls are more than stable, and point out the reason why.

The problem having been thus solved, a factor of safety may be introduced in the formulæ, which will allow for shocks, irregular workmanship, and uncertain material.

The problem may be considered under these several heads:—The angle of rupture, the height of the prism of rupture, and the direction and point of application of the pressure of the prism.

Angle of Rupture.—This was first supposed to be the angle of repose with the vertical. The thrust was assumed to be horizontal, and at two-thirds the height of the wall.

Belidor assumed the angle at 45°, and that the earth moved in layers parallel to the line of rupture.

Coulomb first considered the slope of earth, with the attendant physical conditions. His theory, as amplified by M. de Prony, is discussed by M. Gauthey, who gives a clear analysis of the angle of rupture.

Supposing the resistance of cohesion is proportional to the surface of rupture, and the friction to the normal pressure: the pressure against a retaining wall is that of the prism of earth, which would at once fall if the wall were removed. The inclination of the plane of separation of this prism will vary with the

cohesion and friction of different earths. If a series of planes be conceived less inclined than that of repose, and originating from the same point, one of them will have such a position that the separating prism will have need of a greater opposing force to its sliding motion than any other.

Upon this hypothesis it is proved the prism of greatest pressure is given by the plane which bisects the angle of repose, and that—

$$P = \tfrac{1}{2}\, W, h^2 \tan.^2 \tfrac{i}{2}$$

in which P equals the horizontal force which sustains the prism, W the weight per cubic foot, h the height, and i the angle of repose of the prism.

Lieut. Hope found with layers of coloured sand the average angle of rupture to be 24°, and of repose 54°. This small difference in practice from theory is probably due to the cohesion of particles, an element which from lack of sufficient data, is generally disregarded.

Height of prism of rupture :—From the first it has been assumed that the wall turned over as a solid mass about the bed joint at its base. In practice it is not so ; the line of rupture is a stepped line in or near the natural slope, and leaving a part of the wall undisturbed.

For experiment, a box 16″ high and wide, and 24″ long, with glass sides, was made. A miniature wall of pure blocks or "bricks," 1″ square, 2″ and 3″ long, with a bank of oats or peas instead of earth, in eight trials turned over as stated. When the wall began to move the face bulged out, the centre of the curve being at about one-half the height ; and would continue thus until started forward by a jar. This, due to cohesion of the backing, doubtless adds materially to the stability of walls of long standing, which, it is often noticed, stand, although bulging outward. (This and subsequent statements were illustrated by experiment.)

A solid wall, with a joint at the place of separation, was more stable than one of "bricks ;" for although each began to move at the same time, the first did not continue to give way, and required to be continually started.

Naviers seems first to have noticed that walls rupture in this manner. It is reasonable that the prism of pressure should start at a point above the foot of the wall ; for, by rotation of the wall about the outer point in the base, the lowermost portion of the backing must be lifted.

Experiments made in the case of surcharged walls gave heights agreeing very closely with those calculated upon this basis :—While assuming the prism of pressure to start from the foot of the wall, would give a height far below that sustained.

Direction of Thrust.—If the weight of prism of greatest pressure be resolved into two components, one normal to the slope of rupture, and the other to the back of the wall, the first will resist by its friction the tendency to slip along the slope ; the second is expressed by the formula given, and may be resolved into two other components—one inclined, the actual thrust against the wall ; and one vertical, to overcome the friction along the wall. This latter, from the indefinite knowledge of the value of the coefficient, is generally neglected. The point of application of thrust—at first assumed to be one-third the height of the prism of pressure, which gave too great thickness to the wall—has been shown by Rankine and others to be at one-third the height from the foot. The height of the prism of pressure will be from ·70 to ·75 of height of wall. The conditions of the problem are now determined, from which follow these formulæ :—

$$\frac{t}{p} = -\left(n + \frac{n_1}{2}\right) \pm \sqrt{\frac{2 \tan.^2 \frac{d}{2}}{7w}\left(w_1 + \frac{8p}{3}\right) + \frac{n^2}{3} - \frac{n^2}{12}},$$

in which t = thickness at top of wall, p = any weight per square foot of surface distributed over the bank, n = batter per foot in height of outside, and n_1 = the same of inside of wall ; d = angle of repose, w = weight per cubic foot of masonry, and w_1 = same of earth. If n and $n_1 = o$,

$$\frac{t}{p} = \sqrt{w + \frac{8p}{3}} \tan. \frac{a}{2}$$

and if $p = o$,

$$\frac{t}{p} = \cdot 53 \tan. \frac{a}{2} \sqrt{\frac{w_1}{w}}$$

This would have been ·57 instead of ·53, in case the prism was assumed to start from the foot of wall.

Rankine's theory of earth pressures makes the thrust parallel to the surface of the bank; accepting this and these results :—

$$\frac{t}{p} = \cdot 57 \sin. \frac{a}{2} \sqrt{\frac{w_1}{w}}$$

differing from the usual formula in substituting

$$\sin. \frac{a}{2} \text{ for } \tan. \frac{a}{2}.$$

This gave results very close to those obtained by experiment, and considerably less than those from the formula last given, which perhaps accounts for the general omission to employ a factor of safety.

Transformation of profiles—Vauban's rule, that a rectangular wall may be transformed into one of equal stability, with a batter on the face, having the same thickness at $\frac{1}{3}$ the height, is true within $\frac{1}{120}$ when the batter exceeds $\frac{1}{6}$.

Now, it is usual to give a less batter, and, by taking the common thickness at $\frac{1}{15}$ the height, the error is inconsiderable. (This was proved by experiment.)

In a surcharged wall, if the surcharge starts from the back of the wall,

$$\frac{t}{h} = \cdot 38 \cos. a \sqrt{\frac{w_1}{w}}$$

and experiment verifies this.

Uniformly, when the experimental wall first gave way, the filling did not revolve, as stated by some writers, but settled suddenly, and then rested until another shock started it again, This seems to show the advisability of stepping the back of walls.

Much depends upon the manner in which the work is done after the profile has been fixed : inattention to the details of construction may jeopardize the safety of a structure well proportioned.

For several years pains have been taken to collect data of walls in existence, with a view to establish a coefficient, safe under ordinary conditions, and which may be modified by the engineer to suit particular cases.

Discussion.

Mr. J. Dutton Steele gave a practical rule, verified by his experience, for surcharged walls of dry masonry less than 18 feet high : namely, a width of 3 feet at the top, a batter of $\frac{1}{6}$ outside, and none inside. In one case, for a mortared wall 18 feet high, he reduced the thickness at the top to 2½ feet, and gave a batter to both sides. Engineers who from lack of room have been compelled to lay walls upon narrowed or stepped foundations will be pleased to know, from Mr. Constable's experiments, that such conform to theory, and are safe in practice.

Mr. Collingwood inquired whether it was not best to step the back of a wall, rather than give it a batter.

Mr. Constable said it was more a matter of practice than of theory. By thus stepping a wall, the back filling upon settlement did not act as a wedge.

Mr. Steele said that generally now the back of a wall is not stepped as formerly, but made vertical. Often in railway practice it is counter-sloped or under-cut, and the stability thereby increased. The back should have a "frost" batter at the top, where the earth is likely to freeze, so that it may be lifted from the wall. Care should always be taken in back-filling to slope the packed earth from the wall rather than towards it.

Mr. Colman said that, in filling behind the masonry of N. Y. State Canal locks, broken stone one foot in thickness had been placed between the wall and embankment.

A communication was submitted from a prominent Canadian engineer, in which he said : "In practice I have always made my walls heavier than theory demanded, on account of the severe operations of frost in this northern latitude, where it strikes from three to four feet into the ground; and yet without giving a slope or 'frost' batter to the back of the wall where the frozen earth presses against it, our strongest walls could not stand. It has been my rule to make the base of the wall equal to $\frac{2}{3}$ its height; but this is for first-class masonry laid in hydraulic cement.

Mr. Constable, by experiment with the model, demonstrated that two walls of the same area of section—one rectangular and the other with batter on the face of $\frac{22}{100}$ were equally stable, and also that the saving in material by giving much batter is but little. A wall battered on the back less than on the face evidently is less economical than if all the batter was on the face.

Attention was called to the difference in resistance to crushing per square inch of section of stones "1 and 1¼" cube, as stated in Mr. C. B. Richard's paper, recording "Experiments on the Resistance of Stones to Crushing," read before the society January 8th last. Thus white marble gave a mean resistance in the first of 5,812, and in the second of 8,294 pounds per square inch of section. The question was raised what relation was there between the size and resistance of specimens, and

whether tests upon blocks proportioned like those used in any particular work would better enable the engineer to determine how much the latter could withstand.

Tests of the strength of any material are of greatest value when conducted under conditions most like those governing actual use. The difficulty of making such upon large specimens was pointed out, and a brief method of testing machines was given.

It was proposed to take up the latter as a subject of discussion at a future meeting of the society.

A regular meeting of this Society was held at the rooms in New York, February 19th, 1873.

The Secretary presented the following discussion of a paper "Upon the Character and Position of Neutral Axes as seen by Polarized Light," by Louis Nickerson, C.E., of St. Louis, Mo., read before the Society December 18th last.

Col. MERRILL.—This paper opens a field for examination which promises the most useful results in a matter of vital interest to engineers—the laws of strains in materials used in construction. The plan of using glass to find out these laws brings to mind the practice of physicians in ancient times of determining the laws of the human body by experiments upon those of the lower animals. In examining the action of strains within opaque bodies, the method by analogy seems to be the sole one, aided, of course, by what is visible on the surface and detected after fracture. Further experiments will probably enable us to decide with fair accuracy what is the magnitude of an unknown strain on a glass column, by comparison with the observed effects of a known strain upon a similar column. The proposed strengthening of tubes by external rings at regular intervals is a curious result of the experiments, and, if confirmed by practice, a valuable discovery. The whole discussion illustrates the interdependence of all branches of physical science, and that no discovery is to be considered useless, no matter how far it is apparently removed from a practical application.

Mr. MCALPINE.—The civil engineer has rarely to deal with glass as a material of strength; still, evidently, it will be affected in the same way as any similar material, as cast-iron. It is a characteristic of this age that every discovery in science is made useful to the engineer or constructor. Some years ago Prof. Airey devised a system of measuring the strain in each member of a truss with a model in steel, of which he had exact duplicates. When the model was loaded a member was struck, and the strain upon it measured by the load borne by the duplicate when in accord. There we have *sound*, and here we have *light*, to aid in solving an important problem.

Gen. ELLIS.—Wertheim, of Paris, invented an instrument for the determination of strains and pressures by the colours of polarized light. Mr. Nickerson's examinations are in the right direction, and it is hoped he will pursue the matter further.

What we want to know is, the elastic resistance to tension and compression in any one substance, and the effect of a weight upon a beam of the same substance; then knowing by experiment the elastic resistance in both directions of other substances, we might reason upon the position of the neutral axes of beams made therefrom.

Writers upon the strength of beams err in assuming that equal strains extend and compress the same substance equally; (thereby locating the neutral axis of horizontal strains in the middle of a rectangular beam); also that the elastic and ultimate resistances are proportional.

How can polarized light show a neutral axis in a glass beam supported at the ends and weighted in the middle, instead of a neutral point under the weight? Everywhere in the beam, except at the central point, there are diagonal strains, which will, as well as the horizontal strains, transmit the polarized rays.

The additional element of strength referred to in the paper is, I think, due to the elastic yielding of fibres which in consequence slip upon each other, without a diminution of their ultimate strength; otherwise, in a beam under strain the outer fibres would be ruptured before the others were loaded.

A communication from General Smith, chairman of the committee appointed at the Annual Convention held in Chicago June 5th and 6th last, to urge upon the United States Government the importance of a thorough and complete series of tests of American iron and steel, and the great value of formulæ to be deduced from such experiments, was read, stating that information is required of what has been done in this direction by other Governments, as well as by corporations and individuals here and abroad, of new forms employed, and of new processes of iron and steel-making and their products.

A paper by Gen. W. Sovy Smith, of Maywood, Ill. on "Pneumatic Foundations" was read.

The first two bridges on pneumatic pile foundations erected in the United States were—one over the Santee River, on the North-Eastern Railroad, built in 1855, and the other over the Great Pedee River, on the Wilmington, Columbia, and Augusta Railroad, built in 1857.

The air-lock used in sinking these piles was invented by Alexander Holstrom; it was a cast-iron cylinder, 6 ft. in diameter, and 4 ft. high, closed at top and bottom by cast-iron plates, through which were man-holes opening downward for entrance, and bull's-eyes of glass for light; two goose-neck pipes passed through the sides and bottom, one for introduction of air, and the other for the discharge of water when it would not escape through the material underneath the pile. A windlass was attached for raising the earth within the pile, all of which was removed by hand. There were four air-pumps, set in a single frame, of such excellent construction that they served for the sinking of two foundations, those of the Third Avenue Bridge, New York, across Harlem River, and of the Leavenworth Bridge across the Missouri River, and are now being repaired for use for sinking the piles for the Little Rock Bridge across the Arkansas River.

Construction of the pneumatic pile piers for a bridge over the Savannah River, on the Charleston and Savannah Railroad, was begun in the fall of 1859. The air-lock used was 6 ft. instead of 4 ft. high, and, to save weight, the cylinders of wrought instead of cast-iron. Two defects were soon apparent: one, practically no natural light was admitted into the pile through the bull's-eyes in the air-lock plates, those in the bottom being covered with dirt most of the time; another, the air-lock was too small to stow the material raised, so that, when discharging the same, work in the pile was much delayed.

To overcome these defects an air-lock was made of less diameter than the pile, so that an annular space was left between the two, in the plate covering the top of the latter, into which bull's-eyes were introduced.

Through the side of the air-lock was a pipe or trap, inclined at an angle to discharge readily any material put into it, and arranged for closing at either end. The outer end being closed, the trap was filled with material; the inner end was then closed, the compressed air thus cut off from the air-lock liberated, and the outer end opened, when the material would pass out. By reversing the process the trap was made ready to receive material again.

By this modification no artificial light was required during the day, and at night it could be reflected into the pile, without the inconvenience of candles or lamps burning in a compressed atmosphere.

No detention occurred from this or from voiding the material raised, and nearly thrice as much work was done in the same time as with the Holstrom air-lock.

It was soon found that the sandy material through which these piles were sunk could be raised by the escaping compressed air through a discharge pipe, and delivered outside in a continuous stream; for this the mouth of a flexible tube fitted to the lower end of a fixed pipe was thrust into the wet sand, and moved from place to place as the material disappeared. The ratio of work done to that with the old air-lock, which before was as 28 to 10, now became as 28 to 1.

The improvements thus introduced have been generally used since by General Smith in sinking foundations by the pneumatic process. For the flexible tube, one iron pipe sliding into another, with a hempen gasket between, has been substituted with still better results; thereby seven men have excavated six cubic yards per hour for several hours; by hand, $\frac{2}{3}$ of a cubic yard per day per man is about the rate.

The late war interrupted this work, and also prevented consideration of a plan submitted to the United States Lighthouse Board in 1860, for the erection of a lighthouse on Frying-Pan Shoals, or a similar position on the coast, embracing the sinking of a caisson, from 30 to 50 ft. in diameter, to any required depth less than 100 ft. inside of which a masonry foundation of dovetailed stones was to be laid.

Soon after the war the plan was adapted to the repairing of Wangoshanee Lighthouse, located at the western entrance of the Straits of Mackinac, upon a rocky reef $2\frac{1}{2}$ miles from shore. It is a brick tower, 24 ft. in diameter, 84 ft. high from water surface to focal plane, and stands upon a foundation 24 ft. square, consisting of a crib filled with concrete and rubble masonry. This crib was surrounded by others filled with loose stones, all framed together into one pier 100 ft. square.

At this time the timbers, put in place in 1848, were decaying under the action of seas as heavy as any upon the northern lakes, and the ice; the utter destruction of the pier was threatened.

It was proposed to protect the tower from waves and ice by surrounding it with a strong sea-wall, 66 ft. long and 48 ft. wide on the outside, 8 ft. thick, and semi-circular at the ends. An annular pneumatic coffer-dam of boiler iron was built up in place around the tower, large enough to enclose the wall. It was provided with two air-locks, each having a rectangular trap,

through which material and workmen passed, and a windlass driven by steam. The dam was suspended by chains from beams resting upon the woodwork of the old pier, and, with stones, loaded somewhat in excess of its buoyancy. For 6 ft. below the water surface the crib timbers of pine, 12 × 12 in., built up solid, and strongly drift-bolted with round 1 in. iron bolts, had to be cut through. The reef then reached was made up of boulders varying in size from a hen's egg to 10 tons weight —the large ones, when found under the edge of the caisson, were first split with plugs and feathers, or undermined, drawn into the caisson, and then split. In some instances, where large stones rolled against the dam and kept it from sinking, the dam was allowed to rise, and the stones were rolled inward.

The dam was sunk to a depth of 12¾ ft. below the water surface and 6 ft. below the foundation of the tower, which, though not upon bed rock, as expected when the work was begun, was where the boulders (which had lessened in size as the depth increased) were most perfectly compacted together, and below the scouring action of the waves, from which the dam was protected by the remaining portion of the cribs. The bottom of the dam was then sealed with two successive layers of the quickest setting Louisville cement, each 6 in. in depth, and set under water, which, when the air pressure was reduced, entered through holes left for it in the layers.

It was found the 12 in. of cement thus laid would not, after four days' setting, resist the pressure of water outside; hence the first three courses of masonry, each 2 ft. thick, were laid in a compressed atmosphere. The stones were dowelled together with iron pins 2½ in. in diameter, the end of each pin was drilled 1 in. in diameter, 3 in. deep, and sawn, so that when in place, and a taper bolt was driven therein, the dowell was permanently enlarged.

When the wall was finished, the space between it and the tower was filled with concrete and covered with flagging. The coffer-dam, which might have been removed for use elsewhere, was left in place.

Work could only be done in the six months beginning with May, and frequently it was interrupted by storms. During the first season the chamber to receive the dam was excavated, the machinery was put in place, the dam built and sunk 4 feet. During the second season the sinking was concluded, and seven courses of masonry laid. And during the third season, the work was entirely finished. An average force of forty men was employed. The entire cost, including a new dwelling for the light-house-keeper, was less than 200,000 dollars. This is the first instance of the sinking of a pneumatic coffer-dam or caisson in this country.

After the completion of this work General Smith, in 1869, proceeded to put down at Omaha, for a bridge across the Missouri River, the first pneumatic piles sunk west of the Alleghany Mountains, and to a depth greater than ever before reached—82 ft. below the water surface. The material was very difficult to penetrate. It consisted of a fine silt, stratified with layers of coarse sand and tough blue clay, the latter not more than 2 ft. deep, and with a stratum of pebbles or gravel 1½ to 2 ft. deep next to the bed rock.

The first pile went down vertically. The second, after sinking 27 ft., took an inclination, which could not be corrected in the next 20 ft. by the various means applied; which, although they failed here, in many other cases have succeeded at a depth of from 40 to 50 ft. Generally, the most effective method is to excavate the material under the pile, and, with heavy wooden wedges, firmly wedge up the lowermost edge; then, by letting the air escape suddenly, bring the atmospheric pressure and the weight of the pile to bear like a blow. In this case the silt came in so rapidly as to carry the wedges before it.

Another cylindrical section was put in place, thus adding 10 ft. to the length of the pile, making it 16 ft. and with the air-lock, 22 ft. above the earth surface. A strong frame of 12 × 12 in. timbers was laid down for a fulcrum, blocks and falls were attached to the air-lock, and a severe strain was put upon the pile. The material was again excavated, and, instead of the wedges, a strong beam, cut to the segment of a circle, put down. The pressure was let off and the pile descended, but without any correction of the inclination, although the timbers of the fulcrum were broken.

A pine strut, 8 × 8 in., 11 ft. long, was set at a slight angle —its top against the leaning pile, and its foot against the pile already in place—without avail; and at last the cylinder broke off 27 ft. below the surface where there was a "cold strut" in the metal.

With 15 ft. of sand in the cylinder, 45 lbs. air pressure to the square inch did not lift the piece broken off; but 27 lbs. were sufficient after the sand was removed.

This is the only opportunity he has had to measure approximately the friction on a cast-iron pile. The friction per square inch of surface in contact before the sand was removed was greater than 1·77 lb., and after, it was less than 1·39 lb. This friction must vary with the depth of material, and is diminished when the earth is loosened by the passage of air currents through it. The case instanced differs from that of a pile in place under a load. An important subject of inquiry is, what should be taken as the safe resistance of such a pile in sand to sinking alone, where no bed rock can be reached? as along the lower Mississippi, and on the Gulf coast, it may be desirable to sustain structures upon piles or caissons resting wholly in and on sand. The next two piles were put down without great difficulty—one at the rate of 10 ft. per day. To cause the piles to sink, they were loaded by filling the cylinders with stones, except a central passage or well-hole. Frames built within the cylinders kept the stones in place. After reaching a certain depth it was necessary to increase the downward pressure on the pile by allowing a portion of the compressed air to escape; the pile would then sink from 2 to 4 ft. at a time. The top of the bottom cylinder was covered with a cast-iron diaphragm, through which there was a man-hole, closed by a valve opening inward, which, when shut, prevented more sand from entering the pile while sinking than would fill the lower cylinder; thereby the tendency to "lurch" and the disturbance of outside material was lessened.

At this stage of the work Gen. Smith was succeeded by Mr. Thos. E. Sickles, who successfully employed levers in forcing the piles down, and corrected the inclination by drilling holes through the higher side at different heights, through which the compressed air escaped, loosened the outside material, and thus lessened the friction against the pile.

Gen. Smith then sank the piers for the railroad bridge across the Missouri river at Leavenworth, Kansas—three in number—(two in the river, and one on the east bank)—upon which, and a stone abutment, three spans, each 340 ft. long, were erected. This was finished in two years after its commencement. The difficulties encountered were similar to those at Omaha.

The following conclusions are deduced from an experience of fourteen years in sinking pneumatic pile foundations:—

1. The greatest difficulties to be overcome are: first, in keeping the pile vertical. For this it should be made to follow the excavation, without a reduction of air pressure; and secondly, in righting the pile when inclined;—for this wedging under the bottom, or propping the top on the lowermost side and drilling through the uppermost side, are the best means yet tried.

2. The "air-lift," as described, is the cheapest and most efficient method of removing sand or mud from within a pneumatic pile or caisson.

3. A strong and reliable pier can be always built of pneumatic piles, their number, diameter, and the thickness of metal being determined by the conditions of the case.

4. In cold climates these piles may be fractured by frost, to prevent which a filling below the frost line, from two to five feet deep, of asphaltic concrete, is recommended.

5. Where suitable timber and stone are to be obtained at reasonable prices, a single pneumatic caisson can be sunk with greater certainty, and at less cost, than a pier of three or more pneumatic piles, where it has to be sunk for a considerable depth through a soft material to a hard one—a pier of masonry on such a wooden caisson, cellular, with its walls well drift-bolted, and its interior carefully filled with concrete or rubble, is the cheapest and best bridge foundation yet devised.

6. Concrete does not set well under air pressure. The water was let in through a pipe inserted, therefore, in the cement, to cover the successive layers as put down—usually cement 5 ft. in depth would seal the pile—the remainder was added in the open air.

Discussion.

Mr. Martin.—The first work he had to do in sinking the pneumatic pile piers for a bridge across the Savannah River, on the Charleston and Savannah Railroad, in 1861, was to straighten up a cylinder, which was about 30 ft. in the sand, and considerably inclined.

The method described by General Smith of excavating underneath the lowermost edge of the pile, wedging it up firmly, and then, when severely strained in the right direction by strong tackle, causing the pile to go down by suddenly letting the pressure off, did not succeed, although the pile descended two feet or more. He then excavated under the upper edge as much as possible, so that the escaping air passed through and loosened up the material on that side, wedged up and strained the pipe as before, and, with a battering-ram made of a 12-in. square oak timber, 12 ft. long, and in the middle suspended from shear-poles, struck successive blows against the top of the pile; while it was descending; it was thus quickly brought into position.

A pneumatic pile is easier kept vertical than straightened afterwards; in most cases it may be guided in its descent by a platform attached to wooden piles driven around it.

General SMITH presented a plan for sinking to any depth pneumatic piles and caissons through sand, whereby the excavation is made without exposing workmen generally to the injurious effects of compressed air, which increase with the depth, and below 60 ft. are dangerous.

For a pneumatic pile there should be a short section at the bottom, covered with a plate, through which there are a manhole and valve, a supply and one or more discharge-pipes, the latter made telescopic and with joints, so that a workman standing on the plate may cause the mouth of the pipe to traverse the surface to be excavated beneath the pile.

Thus air forced into the closed section through the supply-pipe would escape through the discharge-pipe, and carry with it the material to be removed.

In a caisson the same principle may be carried out. Men need enter the compressed air chamber only to remove an unusual obstruction.

Such a method is required in sinking foundations to very great depths. The greater the depth the more efficient is the *air-lift* described.

Of course this plan cannot be adopted where the material to be removed will not yield and flow with an air current.

A paper by Robert Cartwright, C.E., of Cleveland, Ohio, on "The Manufacture of Pneumatic Piles," was read.

The bridging of the Missouri River was a necessity to the railroads connecting the east and west of this country. The river is a rapid-running, turbid stream, with a bed of treacherous, shifting material, and a channel which changes at every flood.

The bridge at Omaha has eleven spans 250 feet long, and at Leavenworth three spans 340 feet long; both posts truss upon pneumatic pile piers. The manufacture of cylinders for these is here described.

First there was built a brick pit, 47 feet internal diameter, and 14 feet deep, water-tight, with a foundation in the centre for a 25-ton crane, and four buttresses therefrom, dividing the pit into quarters, each to take two moulds.

For access to the moulds, and to supply air during casting and subsequent cooling, there was a tunnel from each quarter to a shaft sunk outside of the pit. Each mould was built of fire-brick, laid in loam, upon a level cast-iron bed-plate, and covered with another similar plate, the two being firmly bolted together. Outside the mould was a casing of sheet iron, a space of a foot between the two being filled with spalls, cinder, and moulding-sand, which allowed the passage of escaping gases; the remaining spaces in the pit were also filled with sand. From the centres of each bed-plate up to the top of the mould was a vertical wrought-iron shaft, upon which the core barrel centred. The inside of the mould was coated, about $\frac{5}{8}$ in. thick, with loam, brought to a true surface with a "strike" board revolving about the shaft. That the castings might be of uniform section under the difference of ferro-static head, the diameter of the mould at the bottom was made $\frac{3}{16}$ in. less than at the top. The core barrel consisted of six or more staves, or circular segments, strengthened by ribs cast on them, and bolted to two circular spiders, which were attached to a central hollow shaft bored to receive the shaft fixed in the bed-plate of the mould; the whole being so arranged that the hollow shaft and spiders could be withdrawn together, and the staves left in position, to be afterwards removed singly. The barrel was coated with loam to which a small quantity of chopped hay had been added, no rope being used.

When the mould was coated and dried, and the core in place, it was covered with a plate or trough, coated with loam, and well fastened down. Through this were twelve holes, $1\frac{1}{4}$ in. in diameter, for pouring "sprues," and six elliptical holes, about $3\frac{1}{2} \times 1\frac{1}{2}$ in. for "risers;" the last were about 12 in. high, and 6 in. diameter at top, and were an effectual substitute for a "sinking head." A casing was then placed about the covering plate, forming a "runner" around the whole top of the mould, connected with a pouring basin which had two outlets, each stopped by a "straining" gate to retain the slag.

The mould was filled to the top of the risers, the iron entering simultaneously at twelve equidistant points, and, as shrinkage took place, fresh metal was supplied and "churned" with cooled rods. When the iron was "set," the runner casing was taken away, the "sprues" and "risers" broken off with a sledge, and in rapid succession the covering plate and the several parts of the core barrel removed, leaving the red-hot section just cast in the mould, and free to shrink uniformly as it rapidly cooled, without danger to its shape or soundness. In about fourteen hours after pouring, the section (weighing nine tons) was taken from the mould, which was then freshly coated with loam; the bricks were usually hot enough to nearly dry it. As its parts were withdrawn the core barrel was put together, and then coated with loam, which was almost dried by the heat retained. The barrel was then placed vertically on a car, and run into the core oven which was large enough to receive four.

The loam was prepared in a loam mill, consisting of a revolving pan and two heavy cast-iron chasers; it was, with the addition of a little fresh material, repeatedly used.

With eight moulds and six core barrels, one and sometimes two sections were made daily for months; 281 sections were cast, $8\frac{1}{2}$ ft. in diameter, 10 ft. long, some $1\frac{3}{4}$ in. and the others $1\frac{1}{2}$ in. thick, each with a $4\frac{1}{2}$ in. inside flange, $2\frac{1}{2}$ in. thick, at each end. Of these only one was lost, and this by the breaking of a brace after the mould was nearly full. The two flanges were faced in a lathe at the same time, and then each drilled with 61 holes for $1\frac{1}{8}$ in. bolts.

A paper by C. D. Ward, C.E., of Jersey City, N. J., giving "Description of Screw Piles for Supporting a 24-in. Water Main across the Providence River, Providence, R. I.," was read.

The piles were placed in a single row, 12 ft. apart, with a cap or rest on the top of each, in which the water-pipe rests. They were each 22 ft. long, 10 in. exterior diameter, 1 in. thick, and weighed about 2,500 lbs. The largest diameter of screw was 3 ft., and the pitch was 10 in.; there were two threads, each making about $\frac{3}{4}$ of a turn.

The piles descended from 6 to $8\frac{1}{2}$ in. per revolution, and were put down by eight to twenty-one men with ropes attached to levers $10\frac{1}{2}$ ft. long; the direction of draught reduced the effective leverage to about $7\frac{1}{2}$ ft.

Twelve piles were put down, from 9 to 12 ft. each, in sand and gravel, in five days. When regularly moving, the ordinary rate of sinking was about 2 ft. per minute.

STEAM IN THE ENGINE: ITS HEAT AND ITS WORK.[1]

THE author of this little work, "having felt for many years how insufficient our present theories are, and having tried in the most simple manner to compare his own practical experience with the data from Joule's and Regnault's experiments," has written it for the purpose of bringing before the world "a series of calculations made with the data given by Regnault from his experiments, and compared with the results of J. P. Joule's experiments on the mechanical equivalent of heat." He has also, he says, carried out the calculations derived from those experiments, "so far that they become useful to the practical engineer."

Our author dispenses with formulæ, as he considers that no one is in perfect accordance with the true nature of the steam; indicator diagrams, again, taken from the cylinders of working steam-engines, being subject to variations, either by loss of heat by surface radiation, or by a superheating of the steam, are also dispensed with; and the author bases his calculations on the action of steam in the cylinder, on the principle of the mechanical theory of heat, and on the data supplied by Regnault's experiments on the constitution of steam. It appears to us, however, that the author dwells too much on a question of definition. He maintains what is no doubt true, that the steam admitted into a cylinder, and whilst it is being admitted, is merely pushed out of the boiler into the cylinder, and does not in itself perform any work during the period of admission, supposing that the pressure continues uniform during this period; that the admitted steam is, in fact, merely a medium for the transmission of pressure which in reality takes its origin in the steam simultaneously generated on the heating surface of the boiler. He accordingly criticises the late Professor Rankine, and Clausius, for not reducing the work represented in the indicator diagram "by the amount of work consumed as heat in the boiler, when comparing the work performed by the expanded steam with the heat disappeared in it. The natural consequence," he adds, "was an erroneous theory, which carried with it a great misunderstanding of the action of steam when employed to transform heat into mechanical work."

It appears to us, on the contrary, that the difference between the author and those learned professors may be reduced to a narrow compass; and that whereas the latter contented themselves with assuming, for simplicity of calculation, that the work actually done in the boiler in generating steam to replace that which is pushed into the cylinder was performed and was represented by the portion of steam actually admitted, the author prefers to distinguish "the work from the steam" per-

[1] *Steam in the Engine: its Heat and its Work.* By P. Käuffer. Blackie and Son, London, Glasgow, and Edinburgh.

formed in the cylinder during expansion from "the work from the boiler" performed during the admission of the steam into the cylinder. But the author will speak for himself:—

"The late Professor Rankine and Clausius did not reduce the work represented in the diagram by the amount of work consumed as heat in the boiler when comparing the work performed by the expanded steam with the heat disappeared in it. The natural consequence was an erroneous theory, which carried with it a great misunderstanding of the action of steam when employed to transform heat into mechanical work."

And again:—"The very first law and principle of the mechanical theory of heat cannot allow of a transformation of latent heat into mechanical work. Both these gentlemen have accepted *bonâ fide* Mayer's speculation on the very basis of the theory they have developed, and further, they calculated the whole work represented by the diagram as the work given out by the steam inclosed in the cylinder after the cut-off, overlooking entirely that the work performed during the admission has been consumed *before* as heat in the boiler, till the cut-off took place. They could not fail, consequently, to detect far more work as being performed than the steam really lost as heat, and being unable to discover where this *plus* has its source, they assumed that latent heat (of which so great an amount exists in the steam) was transformed into work, and having found liquid water in the cylinders of expansively working engines, that water was at once produced as the result of that transformation.

"Before proving that this assumption has been a premature one, I will state first, what cannot be denied, that there are many other reasons why water may be found accumulated at the bottom of a steam cylinder, and especially in those cylinders where the steam has expanded down very near to the pressure into which it exhausts, as it then leaves the engine with very little energy. In an engine expanding the steam to low pressure, the water (either mixed with the steam or resulting from surface-condensation) accumulates to a certain height in the cylinder: but in an engine driven entirely by the boiler, if water is in the steam, it will not precipitate so easily as in the low-pressure steam, and so it leaves the cylinder as quick as it came in—with the outrushing steam.

"This being stated, I shall endeavour to show that it is really impossible that a part of the latent heat of the steam helps this same steam to push forward the piston, on which it acts, or to overcome the resistance opposed to the advance of this piston.

"I will have to follow up the whole action which the heat, developed by the consumption of fuel, performs in the boiler.

"The fire being lighted on the grate, the water gets warm and expands slightly the more it is warmed, until it reaches at 212° Fahr. a volume of 1·047 times its volume when about 52° Fahr. warm. But now this expansion ceases and a considerably greater expansion begins—that is the vaporization. The water begins to boil, and water in so-called gaseous state, steam, leaves the surface and mixes with the air inclosed in the boiler, above the water.

"The water, when undergoing this change from the liquid into the gaseous state, in consequence of increased molecular energy, becomes so divided that at 212° Fahr. it occupies 1,696 times its first volume. This enormous increase in volume causes an immediate rise of pressure as soon as the steam-space is filled with steam. The compression of this steam causes it to rise in temperature, and, more heat being supplied to the water, its energy increases, and more steam is sent out into the steam-space. Thus, *after the necessary period of time*, we obtain by simply applying heat, a *mechanically compressed* steam of, say, 5 atm. pressure, which steam has then a temperature of 306·05° Fahr.

"The water *can no longer boil* at this pressure, *unless it has a temperature of more than* 306·05° Fahr. and a uniform temperature and equilibrium will exist in the boiler if no more heat is supplied to the water. No further vaporization will take place; and the existing steam will not further be compressed, because no particle of the water is superior in energy to the steam, and if no heat is lost, both water and steam stand together in equilibrium one to the other.

"If these few words have made the action sufficiently clear, it will be understood that the heat of the steam, however warm the steam may become by increased pressure, was not obtained by contact of the heated plates with the steam, but that *this heat has been the consequence* simply *of the mechanical compression of the steam* already in the steam-space when, by superior energy (heat), the most heated particles of the water could no longer remain in a liquid state, and went off as steam, being pushed all round by water of the same superior energy. Of course, the steam generated at the now increased pressure cannot but have the same temperature as the already existing steam; and indeed it is most probable that it has been generated by a greater energy, because (by its generation) it compresses the other steam formerly made in order to make room for itself. This is done in the same moment as those particles of water cease to be liquid, and therefore the heat equivalent to, and spent for, this mechanical compression is consumed in the water itself, and, of course, near to the hot plates. This heat, which had to be spent besides the latent heat, must with that latent heat be entirely contained in the steam upon which that mechanical compression acted.

"As we have seen, the action of the heat upon the water is, first, to make steam out of the water (an internal work which does not further expand the liquid in our thermometer, as here the energy is not increased in intensity, as there is only a real accumulation of energy of the same intensity); secondly, to make room according to the increase of volume of the vaporized water; and, thirdly, as a consequence, to raise the pressure and temperature of both the existing and newly generated steam, according to the limited space in which the total weight of steam must find room.

"During this compression of the steam its latent heat changes. It *diminishes* sensibly, and we find that a part of the latent heat changes into sensible heat, which is easily calculated with the data obtained by Mr. Regnault's experiments. From 1 to 2 atm. total pressure, the difference in total heat is given as 1,158·3094 — 1,145·7 = 12·6094 units per lb. of steam. The latent heat at 1 atm. or 212° Fahr. is 965·7 units per lb., and at 2 atm. or 249·77° Fahr. it is only 941·13936 units. The difference of the latent heat in the two steams is 965·7 — 941·13936 = 24·56064 per lb., where the difference in total heat is only 12·6094 units, or about the half. As 12·6094 units were to be imparted by compression (with new steam) to the steam of 1 atm., the heat called 'set free' in the steam of 2 atm. is 24·56064 + 12·6094 = 37·27004, of which about two-thirds are furnished by the latent heat of the 1 atm. steam. Therefore, if I use, with Mr. Rankine, the expression that heat is 'set free' (not longer latent), I have to say, '*heat is set free during the* compression *of the steam*,' and it is impossible to admit that heat is set free during the *expansion* of the steam, as Mr. Rankine states.

"Latent heat is set free when the molecules are brought closer together by mechanical compression, and heat is bound or transformed into latent heat during the reversed operation, which is the expansion.

"In an engine working with full steam all along the stroke no heat is bound in the steam, because the steam is in communication with the boiler all along the stroke until it leaves the engine; and the steam does not lower in pressure, does not occupy or take a larger volume, because it is not shut up in the cylinder, and thus its latent heat is not required to increase. Here all the work performed by the engine is due to the increase of volume of the water alone.

"In the expansively working engine, the work performed during the admission is due to the same cause; but there, after the cylinder is partly filled, the communication with the boiler is cut off, and the work performed after this moment is due to the former compression of the steam in the boiler; and a part of the free heat in the steam inclosed in this cylinder is transformed into work, whereas the other part of this free heat changes into latent heat in proportion to the increase of volume, because the molecules of the steam withdraw one from the other and want to vibrate in a larger circle, in order to remain in equilibrium with the resistance or weight supported per square inch of contact with it.

"We shall not forget that the transformation of heat into work does not take place in the cylinder, but in the boiler alone. Our engine is only a means of dividing the work imparted to the steam into a product of a limited length of way (speed per second), multiplied by the number of pounds which press or draw on the piston-rod."

We rather think that Mr. Käuffer misapprehends Professor Rankine's theory of the efficiency of an elementary thermodynamic engine. In investigating the equation for such an engine, the Professor clearly recognizes the total "heat transformed into mechanical energy," as compared with the "whole heat received by the fluid." And in his analysis of the efficiency of heat-engines, he recognizes the "rejected heat of the engine, being the excess of the whole heat communicated to the working fluid by each pound of fuel burned, above the portion of that heat which permanently disappears, being replaced by mechanical energy." Now, in the total heat which is replaced by mechanical energy, there is no doubt that Mr. Rankine included the heat absorbed by evaporation in the boiler, and required for the production of a quantity of steam equivalent to that which is admitted into the cylinder.

With respect to the evaporative power of steam-boilers, our author has, with a great degree of caution, as we think, adopted the low proportion of $\frac{6}{10}$ as the actual evaporative performance of fuel compared with its total heating power, and he deduces

an average of about 6·70 lbs. of water as evaporated per pound of coal. If a boiler be properly proportioned and worked, an evaporation of from eight to ten pounds of water may be effected per pound of coal; though it must be admitted that a much less duty has in many cases been realized. Still, in calculating the work of fuel and steam, it is scarcely consistent to assume superior conditions in the one case and inferior conditions in the other.

We shall, however, leave our readers to study Mr. Käuffer's little work for themselves. It contains many original views which will set them a-thinking, and comprises several elaborate tables, with illustrative diagrams, of the action of steam in the engine, together with a number of useful practical remarks on the efficiency and performance of steam-engines.

EXAMINATION of an ancient Egyptian Perfume.—M. Personne. (*Journ. Pharm. Chim.* 4th series, xv. 254.) The fragment examined appeared to have formed part of a mass which had been originally sufficiently soft to become flattened by its own weight. The surface was wrinkled and chocolate-coloured, and the fracture fibrous, whilst the central portion was white and apparently resinous. This substance was easily inflammable, producing a somewhat disagreeable odour.

By successive treatment with chloroform and alcohol this substance yielded a resinous matter having the odour of olibanum, and another resembling myrrh. The insoluble residue contained chalk, a kind of lime soap, and a little benzoin.

According to a student of pharmacy from Egypt, this kind of perfume is still well known there.

It is prepared, as M. Personne describes, by making a kind of paste of oil and chalk with olibanum and myrrh, to which a small quantity of benzoin is added. The mass is made up into little cakes like biscuits.

INSECTICIDES.—*Pharm. Journ.* 3rd series, ii. 530.) Many of the *Anthemidæ*, such as chrysanthemums, camomiles, etc., possess in the sexual parts of the flower a narcotic matter which has a great effect upon insects, and will even kill small ones. In *Pyrethrum roseum* and *P. carneum*, just within the disc, this matter is found in considerable quantity. In order to prepare the powder to advantage, only the centre of the flower must be used, which must be cut before the seed is fully formed. The Spaniards, to keep off gnats, burn the centres of the flowers of the horse daisy (*Chrysanthemum leucanthemum*); and the powder of the may-weed (*Anthemis Cotula*) has also been used for destroying insects. In some parts of Belgium this plant is fastened by the country people to branches where swarms of bees have settled (after they have been secured), to prevent them from leaving the hive. The Mohammedans and the Tartars have long employed the powder of the *Pyrethrum* against all insects indiscriminately. To destroy flies, gnats, and bugs, they burn it on an iron plate, which they heat slowly in order to produce more smoke.

THE Collection of Mastic at Chios.—M. J. Léon Soubeiran (*Pharm. Journ.* 3rd series, ii. 226, from *Journ. de Pharm.*) Mastic flows from the *Pistacia lentiscus*, a terebinthaceous tree, growing principally in the south of the Isle of Chios, about Cape Mastic, which takes its name from this resin, and is situated about an hour's journey from the city of Chios. According to the natives it exudes, not only from artificial incisions, but also spontaneously from the branches, where it congeals in drops, which, under the name of *dakra* (tears), are gathered separately, and constitute the most esteemed kind. But the bulk of the resin issues from vertical incisions skilfully made with a knife close together round the whole circumference of the trunk, from the root to the branches. A few hours after this operation, which is done about the middle of June, there issues from the incisions a resinous, transparent, aromatic substance, which soon solidifies. After fifteen or twenty days this resin is collected in little baskets, lined with white paper or clean cotton cloths. Previous to this time the ground underneath the tree is covered, so as to prevent the juice which runs plentifully, from being soiled by the earth. If such contamination does take place, care is taken to cleanse it directly it is collected. The production of resin, which is collected by women and children, lasts about six months, and is valued at about £8 to £10 for a full-grown tree.

A turpentine which has enjoyed a great reputation is also obtained at Chios, from the *Pistacia terebinthus*, by means of more or less deep incisions in the trunks of the larger trees.

Errata.—Some inaccuracies in dates inadvertently occurred last month in the article on "The Pig Iron Trade of Scotland." On page 241, ninth line from bottom of first column, *for* 1860 *read* 1760; on page 242, first line of second paragraph from top, "Owing to a proposal made by Lord Henry Petty in 1860," *read* 1806; eight lines further on, "Knowledge of the fact that in 1866" *read* 1806.

Building and Practical Memoranda.

SELENITIC MORTAR.—An addition to the list of mortars and cements of so much value as the selenitic mortar, invented by Major-Gen. Scott, C.B., deserves to be extensively known. The new mortar has now been sufficiently tested, and has borne well the best of all tests—that of long periods of continuous work; besides which, most carefully conducted experiments carried out by Mr. Kirkaldy, and other scientific men have effectually demonstrated its value. In order that our readers may better understand the nature of Gen. Scott's invention, we may just say that any ordinary mortar made from lime, slacked before its admixture with sand is, as our professional readers are doubtless aware, inferior in cohesive power to cements. Sir C. Pasley, however, in his work on limes and cements, expressed his conviction that Blue Lias lime would unite stones together nearly as firmly as would the best cements, if it did not swell in all directions when the attempt is made to combine the two processes of slaking and setting, which takes place in cements without increase of bulk, and consequently without forcing them to split or detach themselves from stones or bricks. The invention of the selenitic method does away with this defect. The history of the scheme is simply this. Gen. Scott was the first to observe, about sixteen years ago, that a limestone incapable of conversion by burning, into a hydraulic lime, might be made to furnish a good cement by simply allowing a small proportion of sulphureous acid gas to pass into the kiln during the burning of the lime. When subjected to this slight modification, instead of slaking or combining rapidly with water, and evolving a great deal of heat, it only undergoes a gradual hydration, unattended by much increase of temperature, and sets precisely like a good cement. After a time it was found that the gaseous mode of introducing the sulphate into the lime was not necessary, because the addition of a suitable quantity of soluble sulphate to the lime after the latter was burned, yielded similar results; it was, however, found necessary to find means of securing a certainty in the influence exerted by the sulphate upon the lime when employed thus on a large scale. By a very simple modification, Gen. Scott has succeeded in overcoming this difficulty. The sulphuric acid, or sulphate, called the selenitising agent, is first mixed with the water to be used in making the plaster or mortar, in the proportion of about 5 per cent. of calcium sulphate, upon the lime used. The lime is then added, and the whole of the ingredients are stirred and triturated together into a creamy paste, to which the requisite quantity of sand is subsequently added. Space forbids our more than glancing just now at the results of experiments, to test the cohesive and other working qualities of this selenitic mortar. We append a table of Major Schaws on the resisting qualities of plasters of the following limes and cements. The trials were made by breaking the plasters with a hammer, and by scratching with a pointed tool.

Name of Lime or Cement.	Nature of Mortar. For one Measure of Lime or Cement		
	1 Sand.	2 Sand.	3 Sand.
Lias lime used in the ordinary manner	4·5	4·0	3·5
Roman cement	6·5	4·5	2·5
Medina „ . . .	9·0	7·7	4·5
Scott's „ prepared from Halling lime . . .	10·0	7·5	7·0
„ Lias lime . . .	10·0	7·7	6·2
White's Portland cement . .	10·0	8·5	8·0

For its tensile strength, we append a table of experiments conducted under the superintendence of Mr. A. W. Colling, Clerk of the Works, at the New Law Courts, on Halling Grey lime, and Lias lime from Barrow-on-Soar, to test this system.

Material and Mode of Preparation.	Measures of sand to one of lime.	Mean resistances in lbs.
Lias grey lime as common mortar .	3	112.00
„ „ Selenitic „ .	6	209·66
Barrow lime as common „ .	3	125·00
„ „ Selenitic „ .	5	283·66
„ „ „ „ .	6	196·00

This valuable process gives to ordinary mortar a strength equal to Portland cement, and at no increase of cost. It has

also the advantage, when used for plastering, of allowing the setting coat to be applied in forty-eight hours after the first coat has been put on. The process has already been introduced in the erection of several large buildings by Messrs. Lucas and other builders, and has been adopted by the London School Board in the schools now erecting in London.

INDESTRUCTIBLE PAINT.—Architectural taste, as exemplified in London and other English cities, is often severely and hardly criticised by public opinion; but a little more knowledge of the conditions under which architects have to design would make critics pause before finding fault. The first thing to be considered is cost, and the natural sequence of business brings forward a consideration of the most suitable material to be employed. Much outcry has been raised because the stone in the New Houses of Parliament is decaying, and ignorant fault-finders say that a more durable material ought to have been employed, altogether overlooking that all the beauty of tracery that is an essential feature of the structure could not have been embodied in any but a ductile material, save at a fabulous outlay.

The architect of any building in a great town, has either to choose ornament at the sacrifice of durability, or *vice versâ*. The soft, ductile sandstones are well suited for an ornate style of architecture; but, owing to the destructive influence of the carbonic acid so largely present in the atmosphere of great towns, such materials rapidly decay, and any contrivance for preserving the softer stones from such decay must prove invaluable to architects. There is at present a company in London, having offices at 27, Cannon Street, who supply three different preparations, known as indestructible paint, enamel paint, and enamel solution. These preparations have been brought out after a lengthened and careful series of experiments, and much investigation of the properties of various pigments, with a view of determining the best constituents of compounds really deserving the title of preservers of stone and woodwork.

Taking the three materials in the order stated above, we have seen samples of materials coated with the indestructible paint, and they gave us the impression of being protected by a paint really worthy of its name. This paint is perfectly acid-proof, and is beyond the influence of all ordinary detergents; whether acid or alkaline, it defies even cyanide of potassium, and resists effectually the action of the weather. Owing to its powers of resistance to acids, it has been largely used in the Royal Arsenal at Woolwich as an internal coating for shells. This paint also resists heat so well, that it is admirably adapted for steam boilers. It has been extensively employed for all the pipes in the subways of the New Holborn Viaduct, and also on the girders and other ironwork of the Thames Embankment. It is in extensive use on the Great Eastern Railway also.

The patent enamel paint has a beautiful glossy surface resembling French-polish, and has been largely used for the ornamental ironwork of the Embankment, of the Holborn Viaduct, Albert Bridge, Fulham Bridge, St. Paul's Cathedral, and of the New Opera House in the Haymarket.

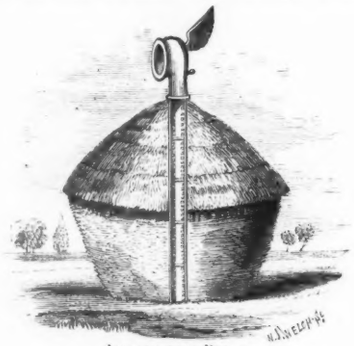
The patent enamel solution is the preparation we referred to above as supplying a want much felt by architects, viz., a means of preserving the softer building materials from decay. This solution soaks into the pores of the material, and effectually seals and plugs them against intrusion of injurious atmospheric agents.

It gives us pleasure to bring these preparations before the notice of our readers, knowing, as we do, that they are really good; for we have examined them carefully. We have seen a piece of stone washed with two coats of the enamel solution and another piece of the same stone unwashed, and there is no room to doubt its value as a preservative.

It has been, and is still being most extensively used in the restoration of St. Paul's Cathedral—upon stone, wood, and *iron-work;* and it appears to be the only one of the many tests applied to the stone-work of the Houses of Parliament in August, 1870, which has really effected its purpose. Visitors to the Annual International Exhibition can see the effect of the solution upon different kinds of stone. Even chalk is hardened by it so that it resists water.

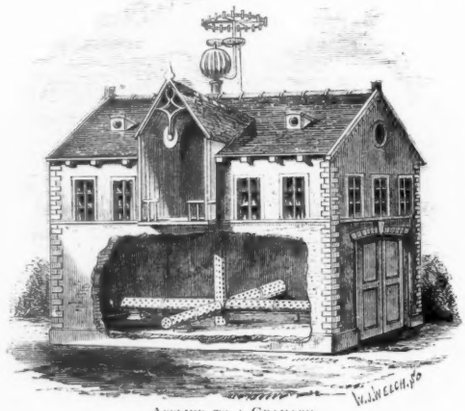
One good quality of this solution is that it does not alter the appearance of any stone, &c., to which it may be applied, whilst it is inexpensive and easy of application.

GRAIN VENTILATOR.—We recommend all who are interested in the preservation, storage, and transport of grain, to give attention to a very neat and simple apparatus invented by Messrs. Adutt, Finzi and Co., of 24, Mark Lane, E.C., for the ventilation of grain and seeds of every kind. It is adapted to ventilate the stack or rick of corn, or will with equal effect keep up a circulation of air in a granary or in the hold of a ship. There is no place so damaging



Applied to a Rick.

to grain, beans, or peas, as the close hold of a ship, and for ventilating such a place this apparatus is admirably suited. It



Applied to a Granary.

consists of a cowl or a windsail on deck, and an air pipe of any suitable diameter passing down from it nearly to the bottom of the ship's hold. At this point four or more horizontal pipes

Applied to a Ship.

are attached, and which are perforated closely with holes all over. Within each pipe is a smaller one, and connected to a small one within the vertical pipe, which does not, however, come quite to the top of the windsail, but turns off and opens out at the side of the large vertical pipe just above the upper deck. Exactly the same contrivance is provided and is built within the stack or rick. If it is wished, a little windmill is set at the top, which rotates a set of oblique vanes, which, when put in rapid motion, force the air down with greater rapidity. The air descends, and escapes into the grain through the perforations, and the foul air can return again through the inner pipe. We are much pleased with the affair, which is simple, inexpensive, and not liable to get out of order.